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OF
CIVIL ENGINEERS

MARCH, 1925

Featuring

Preservative Treatment
of Ties

The Sewerage System of
Westerly, R. I.

Overcoming Ice Difficul-
ties at Holtwood Power
Plant.



Vol. XII

No. 3

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CONTENTS

PAPERS AND DISCUSSIONS

	PAGE
The Preservative Treatment of Ties on the Boston & Maine Railroad. By Frank C. Shepherd	101
The Sewerage System of the Town of Westerly, R. I. By Thomas McKenzie	128
Overcoming Ice Difficulties at the Holtwood Power Plant. By H. W. Lowy	142

OF GENERAL INTEREST

President Coolidge signs Temple Bill	150
Cycles of Run-off and Future Trends	151
Beverly to get Cast-iron Pipe from French Foundry	152
Curb Heights and Automobiles	152
Contracts for State Highway Construction	153
Temperatures in Reinforced Concrete Chimney Shells	153
Proceedings of the Society	156

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JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

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THE PRESERVATIVE TREATMENT OF TIES ON THE BOSTON & MAINE RAILROAD

BY FRANK C. SHEPHERD,* MEMBER, BOSTON SOCIETY OF CIVIL ENGINEERS

NEW TREATING PLANT AT NASHUA, N. H.

THE Boston & Maine Railroad began in March, 1924, the preservative treatment of ties at its new treating plant at Nashua, N. H. This plant has been built primarily for the treatment of ties, but it is planned to gradually extend the treatment work to include piling and other timber used in construction and maintenance work. Eventually there should be a considerable amount of freight car lumber treated there. The New England Wood Preserving Company, which is to operate this plant, expect in addition to develop a considerable commercial business.

The plant is located on the main line of the Boston & Maine Railroad, two miles north of Nashua, and occupies a tract of approximately 100 acres, lying between the railroad right of way and the Merrimack River; being about one mile long and about 1,200 feet in width for a considerable part of its length.

In locating this plant consideration was given to facilities for switching cars. When it is realized that with an average of 700,000 ties treated yearly four or five thousand cars will have to be handled, it is evident that such a plant should, if possible, be located within switching yard limits to avoid disturbance to main line operations, and to reduce the cost of handling the cars by the use of switchers instead of road engines. Careful consideration was also given to locating the yard as nearly as possible at the center of distribution of ties for the entire system.

Another feature which entered into the first cost was that of a location where the amount of grading would be a minimum, which meant an area fairly level, and at about the grade of the main line tracks. It was

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also desirable to find an area where there were no highway crossings, to save the expense of changing them. A very important feature was that of choosing a site which could be readily drained so that there would be no water standing on the surface, this being especially necessary in the seasoning yard. It was also desirable to have a location where the prevailing winds would have the most beneficial effect on the seasoning of ties.

The location at Nashua well fulfills all these conditions and was selected after careful examination of a number of possible sites.

There are really two parts to the treating plant: the storage yard with its tracks, where the ties are unloaded and stacked for air seasoning; and the plant proper, where the treating building is located, together with the tracks necessary for handling the ties to the treating cylinders and to the place where they are loaded for shipment.

Under a contract with the New England Wood Preserving Company, the Railroad purchased and graded the entire site and laid and will maintain the storage tracks; while the Preserving Company, which is to operate this plant, erected the treating buildings and laid and will maintain all plant tracks. Under this agreement the Railroad delivers the green ties in cars on a siding parallel to the main line. Here the Preserving Company, with its own switching engine, a 42-ton Porter locomotive, takes the loaded cars, moves them to the storage yard, unloads and stacks the ties and returns the empty cars to the siding for removal by the Railroad. As soon as the ties are properly seasoned for treatment, the Preserving Company loads them on standard gauge tram cars, especially built for that purpose, and transports them with a Plymouth gasolene locomotive to the treating cylinders. After treatment the ties are loaded by a Brown Hoist locomotive crane on cars furnished by the Railroad and delivered to the siding mentioned above, from which point the Railroad takes them for distribution to points where they are to be used.

LAYOUT OF TREATING PLANT

In the original construction only three of the nine contemplated storage tracks have been laid, giving a storage capacity of about 500,000 ties, while with the completed yard there will be room for over a million ties.

As a protection against fire, an 8-inch water main, connecting with a 12-inch main laid in Pennichuck Street by the Pennichuck Water Works, has been installed throughout the plant, with thirteen hydrants connected, these hydrants having fire hose and reels attached. With the completion of the additional storage tracks another 8-inch line is to be laid between the third and fourth tracks for further protection.

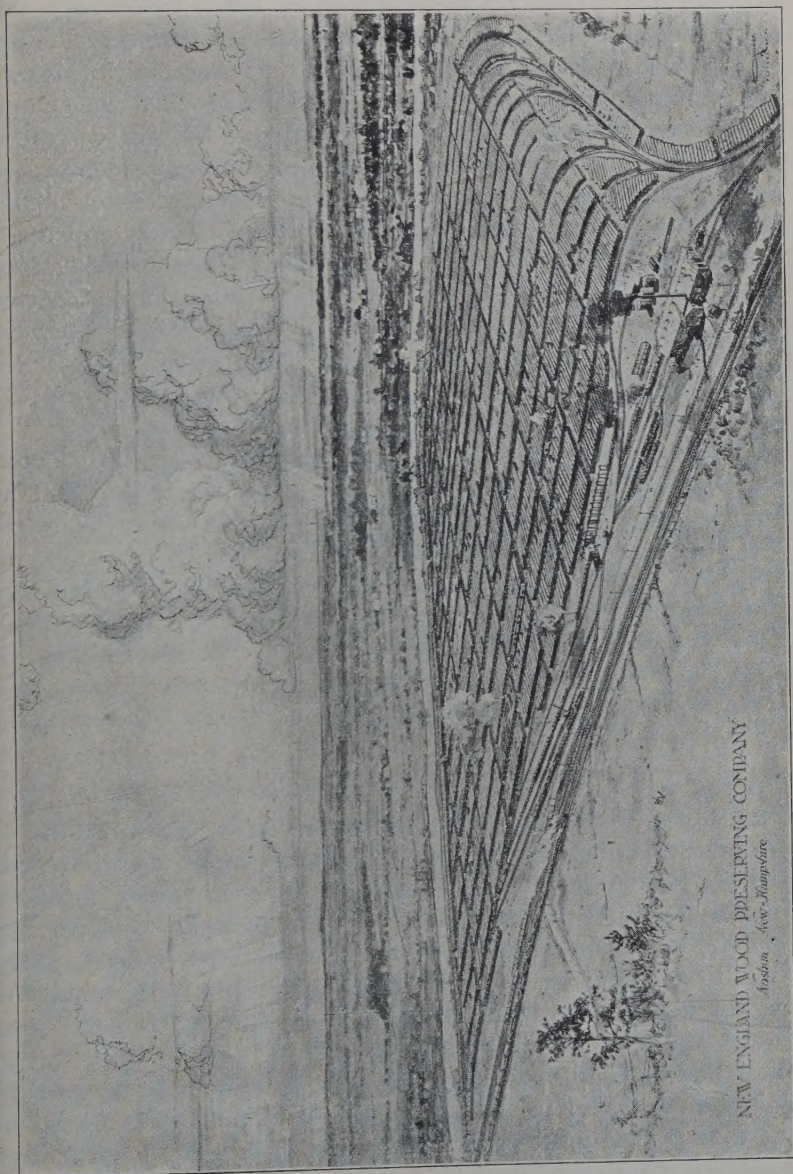


FIG. 1. — BIRD'S-EYE VIEW, SHOWING PROPOSED ULTIMATE DEVELOPMENT

The storage tracks are spaced 110 feet on centers, and the ties are piled on either side of these tracks for seasoning, before treatment. The proper seasoning of treated ties is one of the most vital features in obtaining successful service life, and it is necessary that they be kept in well-ventilated piles, free from every possible infection. To help prevent this all ties should be shipped promptly, after cutting, to the storage yard at the treating plant, and this yard should be kept free from weeds, decayed wood and standing water. In order to provide proper access for circulation of air, and also to have as little of each tie as possible in contact with another, the ties are piled first one and then nine, each pile running from the track back five tie lengths or about 40 feet, with a space of 4 feet between each pile. Each pile contains about 600 ties. Midway between storage tracks and at 300-foot intervals, along the tracks, lanes are left for access in case of fire. All ties are kept off the ground by treated sills, to prevent decay at this point.

The ties are unloaded by professional tie handlers working on a piece basis, and two men working together will readily unload and stack about 950 ties a day. As the ties are unloaded each pile is marked to show the date unloaded and the car on which they were received. This enables the plant inspectors to keep a record of all ties in and out of the yard and to know just when the ties are ready for treatment. Careful record is kept of the ages of the tie piles, for it has been found better to treat ties on the basis of age, as determined from experience, rather than to depend on visual inspection. The time necessary for air seasoning will vary with the kind of wood.

SEASONING OF TIES

Ties or timber should not be treated until sufficiently seasoned, as it is impossible, even under high pressure, to properly impregnate the woods in a fresh or green state. Freshly cut green ties and timber contain a large quantity of water, a considerable part of which must be removed before the timber can be treated with preservative. Seasoning not only prepares timber for its injection with preservative, but also increases its strength, stiffness and hardness, reduces its weight and renders it less likely to check and warp when put in use.

The methods of seasoning may be grouped in two general classes: (1) natural or open-air seasoning, and (2) artificial methods, including kiln drying, seasoning in saturated steam and seasoning in hot oil. Kiln drying is employed in seasoning the finer grades of lumber, but is rarely used in preparing ties and timber for treatment with preservative. Seasoning in saturated steam or hot oil is used when ties must be treated before they

can be properly air seasoned and in localities where air seasoning is difficult or unsafe.

Air seasoning is a safe, economical and very effective method of preparing ties for treatment and is the method commonly used in the United States except in some districts in the south, where conditions are such that the ties are likely to be damaged by decay before they can be seasoned. As soon as timber is cut it immediately begins to lose water by evapora-

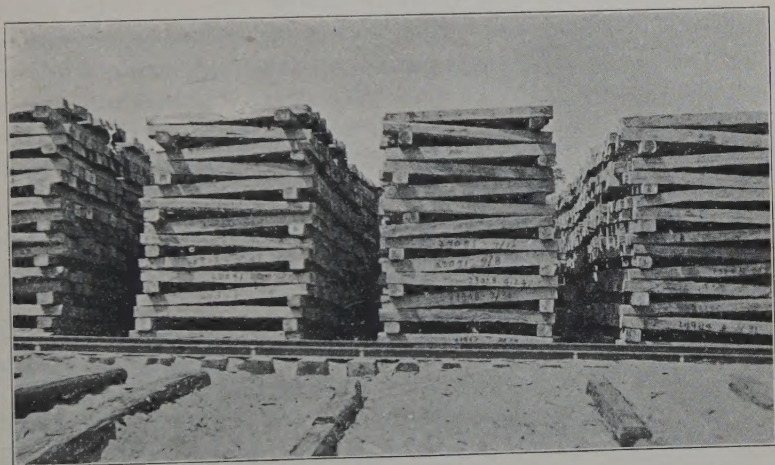


FIG. 2. — TIES PILED FOR SEASONING
Car numbers and dates unloaded shown

tion, and, if it is properly exposed, this evaporation will continue until the moisture content of the wood reaches an equilibrium with atmospheric moisture at which point the timber is said to be air seasoned. Ties should be peeled before they are treated, and, except under unusual conditions, before they are stacked for seasoning. In most cases peeling should be done as soon as possible after the ties are cut in order to save freight and prevent deterioration.

When the process of seasoning in saturated steam is employed, the ties are placed in the treating cylinder and steamed at a pressure of about 20 pounds per square inch, with a temperature of about 250 degrees F, for a period of from two to five hours, depending on the kind of wood and its condition. After the pressure is released the temperature in the cylinder is maintained by means of heating coils, and a vacuum of from 22 to 24 inches is created and held from one to two hours to exhaust the vaporized moisture. Steaming carries with it the danger of injury to the wood. If

the pressure employed is too high or of too long duration, serious checking and marked decrease in the strength of the wood may result. Steaming does not dry the wood and under some conditions increases the moisture content. It should not, therefore, be employed when ties can be air seasoned. For seasoning ties to be treated with zinc chloride, steaming is not so objectionable and is quite often employed to make possible the thorough treatment of partly seasoned ties.

Seasoning in oil is employed on the Pacific coast in connection with the treatment of Douglas fir. The ties are placed in hot creosote oil in the treating cylinder and boiled under a vacuum, the temperature of the oil being maintained at from 180 to 200 degrees, the maximum vacuum being 20 inches. This gradually vaporizes the water in the wood. To oil-season ties properly requires from twelve to twenty hours, and the process is, therefore, a rather expensive operation.

Ties cut from most woods have a tendency to check while seasoning, the checking being caused by the outside of the tie drying faster than the inside. After a time the surface will shrink until it can no longer extend around the comparatively moist interior, and so will be drawn apart in checks. Excessive checking can be controlled and prevented by proper piling and the use of "S" irons. Where the end of a tie shows a well-defined initial check, "S" irons or other similar devices are driven across the check in the end of the tie to prevent splitting during seasoning or after treatment. The commonly used type of "S" iron is made from strips of steel $\frac{1}{8}$ inch thick and $\frac{3}{4}$ inch wide, beveled on one edge and bent in the form of the letter "S," 4 to 6 inches in length overall. Checking of some hardwood ties, particularly ash, oak, hickory and beech, may result in the splitting of the end of the tie. When this occurs the tie may be salvaged and made serviceable by bolting. The split end is drawn together in a large clamp and the bolt inserted.

ADZING AND BORING OF TIES

After the ties are properly seasoned at the plant at Nashua they are loaded on tram cars. These cars are made of cast steel, the entire frame being one casting, and are equipped with Timken roller bearings. Each tram holds approximately 50 ties, the ties being held on by iron hoops so designed that the loaded tram can be run directly into the treating cylinders, the cylinders being 7 feet 6 inches in diameter.

Before the ties reach the treating cylinders they are passed through an adzing and boring plant. This plant with twin units is so located as to make possible the preparation of the ties before treatment, with a

minimum movement of the ties between the storage yard and the treating cylinders. It is served by a single track above which is a monorail-crane runway 300 feet long carrying an electrically operated Pauling & Harnischfeger travelling hoist of six-ton capacity which operates a huge pair of electric tongs. The adzing and boring units are located near the end of this runway, one on each side of the track and crane runway. The single straight track serving the adzing and boring plant is on a grade sufficient to utilize gravity for all movements of the tram cars.

The hoist operating on the monorail-crane runway picks up the ties from the incoming tram cars, a tram load at a time, and dumps them on



FIG. 3. — ADZING AND BORING PLANT WITH MONORAIL CRANE
Also showing building for collecting shavings

the platform between the two adzing and boring machines. As the tram cars are unloaded with the tongs of the traveling hoist, they run by gravity to a point immediately below the platform on which the adzing and boring machines are located and there are reloaded with the adzed and bored ties.

The adzing and boring machines are electrically driven and are the first two machines of an entirely new type manufactured by the P. B. Yates Machine Company. They are located on a platform 10 feet above the ground, each in a separate building, between which the platform ex-

tends. The ties dropped on the platform between the two units are fed into conveyors which automatically carry them into the machines, where they are first adzed at either end under the rail seat, the adzed surface being about one-half inch longer than the tie plates to be used, and then bored for four spikes; then they drop on to conveyors beneath the platform, which carry them to and reload them on the tram cars. These machines have a speed of $7\frac{1}{2}$ ties per minute, and the manner in which the ties are handled to and from the machines makes an almost continuous operation of this equipment possible and gives an output of about 350 ties per hour from each machine. As the ties pass through the machine the year is also branded into the face of the tie. After the tram car is reloaded under the machine, it then runs by gravity from the loading point towards the treating yard.

All the borings and shavings are baled and sold. The equipment for handling the shavings and the space for the storage of the baled material is located in a separate building. The shavings and borings are automatically removed from the adzing and boring machines and collected in a large hopper on top of this building, an electrically driven cyclone sawdust collector being employed. Beneath the hopper is a bin from which the shavings drop into an electrically driven machine which compresses them into bales of about 75 pounds each. A loading platform at this building is located on one of the tracks and shipments of shavings are made as carload lots are accumulated.

The adzing is for the purpose of making a uniform thickness of the ties at the rail seat and to provide an even bearing for the tie plates. With the gradual development of heavier power on railroads it was found that the service life of ties was rapidly decreasing, due to the heavy cutting under the rails. This led, some thirty years ago, to the adoption of tie plates which today are very extensively used throughout the country. With the development of the preservative treatment of ties, while we have reached a point where it is fair to say that the ties will not fail by decay, we still find the ties failing from mechanical wear under the rail, and especially so where no tie plates are used. This failure is not only from the cutting of the tie, but also from the fact that the cutting soon gets beyond the point where the preservative may have reached, resulting in rapid decay as well as cutting. To avoid this, larger tie plates are being continually used and the surface of the tie adzed to a uniform surface under the tie plates. It is poor economy to treat ties and then put them in the track without tie plates.

As illustrating the change in tie plates, the records of the Boston &

Maine Railroad show that the first tie plates used on this road in 1905 were 5 inches by 7½ inches, while the present standard, adopted in 1923, is 7 inches by 10 inches. Some roads are today using even larger plates.

Another serious source of decay found in treated ties is around the spike holes, this being due to the fact that the spike breaks and opens up a part of the tie where no preservative may have reached. The continual moving of the spike and the seepage of water into the pocket thus formed soon results in decay around the spike holes while the remainder of the tie may be perfectly sound. To obviate this, holes about one-half the size of the spikes are bored by template where the spikes will come, this resulting in the preservative reaching the wood around the spike holes.

It is estimated that the boring and adzing adds about three years to the life of a treated tie, and the small additional cost is certainly warranted.

The dating is for use as a reference after the ties are laid in the track. As ties are removed each year, with the date of installation readily ascertainable we shall be able to get records as to the life obtained from the treated ties. Where special tests are being made, dating nails are applied to the ties.

From the adzing and boring plant the ties on the tram cars are then hauled to the treating cylinders, first passing over a standard Fairbanks railroad track scale, where they are carefully weighed. By weighing again after treatment the exact amount of preservative retained in the ties is readily obtainable. All treatment work is based on the amount of preservative retained in the wood.

TREATING PLANT BUILDING AND EQUIPMENT

The treating plant building at Nashua is 40 feet wide and 240 feet long, built of glazed tile with corrugated metal roof and equipped throughout with Swartout roof ventilators. Steel sash and doors are used throughout the building, roller doors being used for the large openings.

In addition to the cylinders and treating equipment, this building also contains a boiler plant, machine shop, store room, locker room for employees and room for housing locomotives. The plant office and laboratory are located in a two-story addition to the main building, while another is used for unloading tank cars of preservative and fuel oil.

In the northerly end of the building are located two treating cylinders 7 feet 6 inches in diameter and 87 feet 6 inches long, with a capacity of 500 average ties, and equipped with heating coils and standard gauge tracks, these cylinders opening at the northerly end so that the loaded

standard gauge tram cars can be run directly into them. When the cylinder is open there is a short piece of track which is removed in order that the doors may swing.

Most of the pressure-treating plants in this country use narrow-gauge equipment with smaller cylinders. While there are arguments in favor of both gauges, the standard gauge appears to us to be more advantageous,



FIG. 4. — TREATING PLANT BUILDING FROM WEST

as it saves having two sets of tracks in the storage yard and two sets of locomotives, one standard gauge serving the storage yard and one narrow gauge serving the cylinders. Usually where the narrow-gauge equipment is used the engines handling the trams are electrically operated, requiring overhead trolley construction, as well as power plant installation. Another important feature is in the length of cylinder required, due to the fact that with the narrow gauge trams less ties can be handled per tram, so that for an equal number of ties for each tram much longer cylinders are necessary. Some plants are using cylinders 150 feet long.

Located above and mounted on each treating cylinder at the Nashua plant there is a Rueping tank used for filling the cylinders and connected with them by a 10-inch filling line. Below each cylinder and located in the basement of the building and mounted on 50-ton Howe tank scales is

a pressure measuring or weighing tank from which the preservative is forced into the cylinder. Between the cylinders there are three working tanks 18 feet in diameter and 22 feet high, each having a capacity of 45,000 gallons.

All the machinery used in the treating operations and all the valves, gauges and appliances that control these operations are located in an oper-



FIG. 5.—VIEW LOOKING TOWARD TREATING PLANT BUILDING

ating room 20 feet by 40 feet in the rear of the cylinders. Under this compact arrangement the treating engineer has instant access to all treating equipment and appliances and is able to control operation in both treating units at all times. Also in this room is a gauge board carrying for each cylinder a recording pressure and temperature gauge, an indicating thermometer and a mercury column vacuum gauge. Also on the board there is a recording and indicating steam gauge and clock.

The preservatives are handled and the pressure is applied exclusively by the use of compressed air. Three automatically, electrically driven Westinghouse traction air brake compressors which are located in the operating room store air in two large receivers which are built to withstand a working pressure of 350 pounds, these receivers being 5 feet by 30 feet and located outside the building.

The vacuum-producing equipment includes three automatically, electrically driven Ingersoll-Rand double-acting vacuum pumps located in the operating room, and connected with two vacuum storage tanks 10 feet by 37 feet 6 inches located outside the building.

The use of the three air compressors and the three vacuum pumps makes it possible to build up and maintain for instant use a pressure of 350 pounds in the air receivers and a vacuum of from 26 inches to 27 inches in the vacuum receivers. The air compressors work entirely on the air receivers, all air pressure used being taken from these receivers. The same is true with the vacuum pumps, except during the application of the final vacuum, when they apply vacuum direct to the cylinder to complete the application.

The boiler plant furnishes steam for heating the preservatives in the storage tanks, operating tanks and cylinders, and also furnishes heat for the office, shops, etc., all machinery throughout the plant being electrically driven. The boiler is an oil-burning 132 horsepower Babcock & Wilcox sectional water tube boiler. A smaller boiler is used for heating the office and main building during the winter months, when the main boiler plant is not in operation.

To conserve heat and facilitate unloading, particularly in cold weather, tank cars are unloaded in the addition to the main building previously referred to. In this addition there are two underground receiving tanks, each with a capacity of 28,000 gallons, into which the tank cars are unloaded by gravity, this making possible the unloading of two tank cars simultaneously. From these receiving tanks the oil is forced by compressed air to all parts of the plant.

A well-equipped machine shop is located at one end of the main building, and the tracks leading into this make it possible to bring locomotives and tram cars into this shop for repairs.

Outside the main building there are three covered oil storage tanks equipped with heating coils and agitating lines with a capacity of 150,000 gallons each, this making a total storage capacity, including the working tanks, of over 600,000 gallons. Supplementing this the Wood Preserving Company maintains and operates a loading dock and two storage tanks with a capacity of 675,000 gallons each, these being located at Portsmouth, New Hampshire, where with over 35 feet of water at low tide it is possible to receive preservatives in tank steamers from European points. The equipment at that point includes facilities for loading four tank cars at one time and equipment for handling preservatives to and from the storage tanks by compressed air, as well as pipe lines from the dock to the storage tanks by which the boats may be unloaded.

Although the equipment at our Nashua plant makes possible the treatment of ties or timber by all the standard pressure processes, the plant was built principally to use the Rueping process,* and at the present time we are treating all ties by this process, with a final retention of 5 pounds of creosote coal-tar solution to the cubic foot of wood.

OPERATION OF TREATING PROCESS AT NASHUA PLANT

As soon as the loaded trams are placed in the cylinders and the doors closed and bolted, the operator, by equalizing the pressure between one of the large air receivers, the cylinder and the Rueping tank, develops at

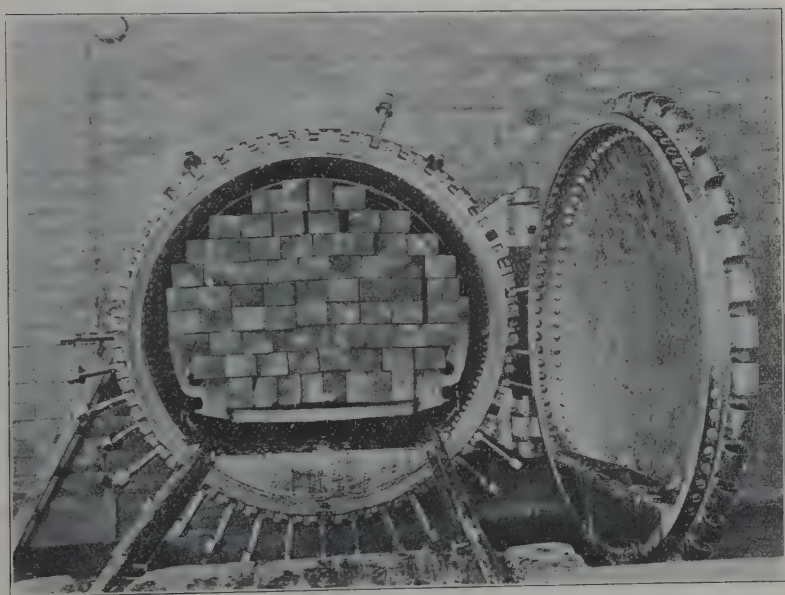


FIG. 6. — CYLINDER OPEN, SHOWING TREATED TIES READY FOR REMOVAL

once an initial air pressure of from 60 to 90 pounds, both in the cylinder and in the Rueping tank, this tank, prior to commencing operations, having been filled with hot preservative oil at a temperature of about 175 degrees. By next opening the 10-inch filling line from the overhead Rueping tank the cylinder is quickly filled by gravity with the hot preservative and the overhead tank is then cut off. Pressure on the preservative in the cylinder is then increased to the required maximum by

* For a detailed description of the various preservative processes in use, see the appendix to this article.

equalizing the pressure between the other air receiver and the cylinder, this pressure being applied through one of the underground pressure weighing-tanks containing hot preservative. Before applying this pressure the amount of preservative in the underground pressure weighing tank is determined by scale readings. By this equalizing of the pressure in the air receiver and the cylinder the maximum required pressure of from 150 to 200 pounds is quickly secured in the cylinder and on the ties, this operation requiring about ten minutes. By continuing to utilize the pressure stored in the air receiver through Mason regulating valves, the exact maximum pressure desired is maintained on the preservative in the pressure weighing tank and the cylinder until sufficient preservative has been injected. The progress of the injection of the preservative into the timber is determined and controlled by scale readings which show at all times pound by pound the exact amount of preservative forced from the pressure scale and injected into the timber, the scales for this tank being in the operating room. The use of the stored air pressure, as explained above, effects a big saving in time by making it unnecessary to build up the pressure from atmosphere during operations. At the same time it makes possible the maintaining of the exact required pressure on the preservative throughout the pressure period.

After the desired amount of preservative has been forced into the ties by the maintained pressure, the cylinder is cut off from the underground pressure weighing tank, the valve in the 10-inch filling line opened and the preservative in the cylinder forced out into the Rueping tank by releasing the pressure in the tank. With the Rueping tank again completely filled with preservative, the additional preservative which collects in the cylinder from the "kick back" automatically drains back into the underground pressure weighing tank, and a scale reading taken at this time shows just how much preservative is retained in the wood, after releasing the pressure. This is usually completed in about one hour and thirty minutes.

A quick vacuum is then drawn by equalizing between the cylinder and one of the vacuum receivers in which a vacuum from 26 to 27 inches has been previously drawn. By such equalization a vacuum of from 16 to 18 inches is at once produced in the cylinder, and this is then increased by the operation of the vacuum pumps applied directly to the cylinder, the result being that a vacuum of from 22 inches to 23 inches is secured in from 12 to 15 minutes, this completing the vacuum application. A vacuum is then equalized between the cylinder and vacuum tank to salvage as much of the vacuum as possible, and the remaining vacuum in the cylinder is then broken.

The preservative ejected from the timber during application of the vacuum is then drawn into the underground pressure weighing tank and a scale reading taken to show the amount of preservative remaining in the pressure weighing tank after the completion of the treatment which, compared with the amount contained therein at the start, gives at once the amount of preservative retained in the timber.



FIG. 7. — OPERATING ROOM

With the vacuum cut off, the door of the cylinder is opened and the ties in the trams removed from the cylinder, these ties being free from dripping oil and ready for immediate loading and shipment away.

The use of the 10-inch filling line, regulating valves and compressed air for the pressure applications and the employment of air receivers and vacuum receivers effect a marked reduction in the time required to secure the required initial air pressure, pressure on preservative, and vacuum, and to fill and empty the cylinders, and makes this treatment possible in a minimum time. During the past summer treating yellow sap pine ties, an average of five charges in each cylinder, or a total of ten charges per day, were treated in one shift of ten hours, plus from thirty minutes to one hour overtime, thus making unnecessary any night operation at the plant. Although during the year 1924 the plant was operated from

March until November, with a total output of 574,795 ties, we find that during the five months from May to September, inclusive, when the plant was in active operation, 512,939 ties, or an average of over 102,000 per month, were treated.

There is a great difference in the action of the various kinds of woods to treatment, so that similar woods only should be treated in the cylinders

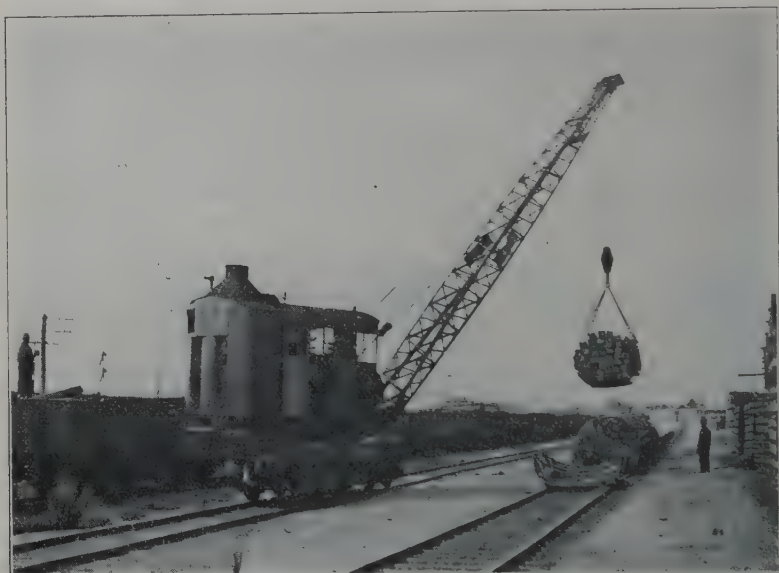


FIG. 8. — LOCOMOTIVE CRANE LOADING TREATED TIES

at the same time. Some woods take preservative very readily, while others, such as fir, oak, chestnut, etc., are very refractory. Generally speaking it is planned to have all sap wood thoroughly impregnated and as much of the heart wood as possible, as it is felt with the sap wood filled there is very little chance for decay. In refractory woods, such as fir, or where the tie is largely heart, the impregnation is aided by the use of perforating machines applied to all sides of the ties.

INCREASE IN USE OF TREATED TIES

The United States today is the largest consumer of wood in the world and at the present time the amount used annually is four and a half times the replacement by growth. This gradual reduction and the increased length of freight hauls has caused a rapid increase in the price of

lumber. One of the factors in the drain upon our forests is the waste due to decay. This is especially true in railroad material and particularly so in ties. In 1908 the Committee on Ties of the American Railway Engineering Association reported that after a careful canvass made through many of the railroads in this country it had found that in the judgment of its members about 87 per cent of first-class tie timber was destroyed by



FIG. 9. — SECTION OF UNTREATED SAP PINE TIE

decay and about 67 per cent of the softer woods failed from the same cause.

Decay in timber is due to the action of low forms of plants called "fungi" which feed on and destroy the wood tissues. To preserve wood from decay it is necessary to prevent the growth and attacks of these organisms. In order to live and develop, wood-destroying fungi require a temperature favorable for growth and certain amounts of air, moisture and food. If one or more of these four essentials is eliminated, fungi cannot live, and, as far as decay is concerned, wood will remain sound indefinitely. The basic problem in wood preservation, therefore, is to eliminate one of the four essentials necessary to the growth of the fungi.

Wood-destroying fungi require but a small amount of air and thrive at temperatures that prevail most of the year. Prevention of decay by

control of air supply or temperature is, therefore, impracticable except in the case of timbers that are deeply buried in the ground or continually submerged in water. It is only by the elimination of one of the other two essentials, moisture and food, that wood may be rendered decay proof.

Wood under roof can be kept dry enough to prevent decay if there is proper ventilation. In the case of ties and structural timbers exposed to the weather, however, the elimination of moisture is usually impracticable. The most effective method of preventing decay in such timbers is to poison the food supply of the wood-destroying fungi. It is upon this principle that modern wood preservation is based, the practice being to



FIG. 10. — SECTION OF TREATED SAP PINE TIE

treat the wood by injecting a toxic chemical which is poisonous to fungi. An effective wood preservative must not only be toxic against fungi, but must be a substance that will readily penetrate wood and at the same time will not volatilize or leach out.

The chemical treatment of wood has been practiced in this country for some fifty years, but due to the cheapness of lumber and the ease with which it could be secured it is only in the last twenty-five years that treatment work has been carried on to any considerable extent. While in 1909 some 76 million cubic feet of timber were treated we find that since that

time there has been a very steady increase, with the result that in 1923 over 224 million cubic feet of timber were treated. At the present time treatment work is increasing very rapidly, there being in 1923 some 135 treating plants in active operation in the United States.

The railroads are today the largest users of treated timber, taking over eighty per cent of the output of these wood-preserving plants, consisting principally of railroad ties and timbers. At the present time over 50 per cent of all tie renewals are treated before installation, and quite a number of railroads have already reached the point where practically all ties in their tracks are treated ties. The main feature of such treatment work is to lengthen the life of the ties, thereby reducing renewal costs. A further advantage is that many of the so-called inferior species of timber may be used in the place of the more valuable species, supplies of which are becoming rapidly depleted or the price of which is so high as to prohibit their use.

KINDS OF WOOD AVAILABLE IN NEW ENGLAND

The principal sources of ties in New England during recent years have been —

(a) Native chestnut — the supply of which, on account of the blight, will be commercially extinct in a few years.

(b) Yellow pine — which is suitable for use without treatment, the commercial supply of which will cease shortly on account of the depletion of yellow pine cross tie timber. For some years past it has been most difficult to obtain a suitable quality without paying prohibitive prices.

(c) Cedar — cedar ties are suitable for branch lines and sidings, and while having a longer life than either the chestnut or pine are not at all suitable for heavy main line use on account of their softness. It is undoubtedly a fact that cedar ties will be available for branch lines and siding use for an indefinite period.

This means that for New England other sources of supply for ties must be developed. The logical source is from the woods available within our own states, or within a short haul thereof. At the present time there is an almost unlimited supply of beech, birch and maple, which, while entirely unsuitable as ties, where they would probably last only three or four years in the track, can, with proper treatment, be expected to last from fifteen to twenty years.

TEST SECTIONS OF TRACK

In the early days practically no records of any sort were kept from which available data could be obtained as to the service life of treated ties. As an increasing number of roads showed interest in the preservation of ties, the question of service life became a very live one, and here and there small numbers of ties were inserted for record purposes.

Unfortunately most of the early test sections consisted of only a small number of ties. Furthermore, the records with reference to these ties were frequently lost and in other cases were not kept up, due to changes in officials. Many of these records were discontinued because the particular company which started them became convinced, after a few years, of the economic value of using treated ties.

About 1904 and 1905 a number of test sections were put in with the modern viewpoint, and since that time several hundreds of such sections have been installed, covering many thousands of ties. These test sections include different kinds of wood, different sizes of ties and different treatments, and in many cases different types of ballast, rail fastenings, tie plates, etc. On many railroads the sections are arranged to take care of varying climatic conditions.

In the early days the test sections were laid largely for the purpose of obtaining figures as to the comparative life of treated versus untreated ties, because in those days tie treatment was regarded as more or less on trial. This no longer is to be questioned. The great value of maintaining test sections at the present time is that by keeping accurate records on these sections, and in that way only, information can be obtained with reference to life of different kinds of timber, different methods of preservation and the influence of such factors as traffic, fastenings and ballast.

Careful annual inspection should be made to secure the exact condition from year to year. The use of treated ties is an economic necessity and duty for railroads, and nothing but treated ties should be laid, regardless of climatic or other conditions.

A study of the completed test records published to date indicates that definite figures as to length of life for the average various treatments cannot yet be given. The life of the most inferior untreated timber can undoubtedly be doubled by treating them with zinc chloride, and in dry climates this will undoubtedly be extended.

Depending upon climatic conditions and the kind of timber treated, the life of ties treated with zinc chloride can be conservatively estimated at from six to fifteen years, and treated with zinc creosote at from eight to

eighteen years. Ties treated by the empty cell creosote processes have not yet been in track long enough to give even a tentative figure, although some have now been in use about eighteen years without approaching an average life.

In the most extensive experimental track laid in eastern Kansas in 1906, with creosoted ties, 96 per cent were still in the track after a service of seventeen years. On another railroad creosoted hard-wood ties laid in 1905 still had 89 per cent remaining in service after eighteen years. This undoubtedly means that the ties treated by the empty cell creosote methods should give a life of from sixteen to twenty-five years.

One of the most interesting results from recent tests is that furnished by the Chicago, Burlington & Quincy Railroad and published by Mr. J. H. Waterman, Superintendent of Timber Preservation. For this test some 20,000 ties were laid on twenty divisions of the road in 1909 and 1910. In 1923, at the end of fourteen years' service, the following records are given as showing ties removed on account of decay:

For Lines East, where the Average Rainfall is 36 Inches

1. Straight creosote, full cell (10 lbs.)	3.9 per cent removed
2. Creosote zinc chloride (3 lbs. — ½ lb.)	8.2 per cent removed
3. Zinc chloride (½ lb.)	23.9 per cent removed
4. Untreated	89.7 per cent removed

For Ties laid on the Western Lines, where the Average Rainfall is 21 Inches

1. Straight creosote, full cell (10 lbs.)	1.7 per cent removed
2. Creosote zinc chloride (3 lbs. — ½ lb.)	8.9 per cent removed
3. Zinc chloride (½ lb.)	14.3 per cent removed
4. Untreated	89.8 per cent removed

ANNUAL TIE RENEWALS PER MILE OF TRACK

While the treating-plant men are interested in the kind of treatment and the results to be expected from it with regard to service life for treated ties, the managements, of course, are more interested in the actual results and the economies that can be shown or expected. This means really for any system the total expense yearly for tie installation or the average yearly renewals per mile of track.

In 1911 the United States Census Bureau reported that the average number of tie renewals per mile of track in the United States for that year was 336. Doubling the life of all ties we should expect to reach an average renewal of 168 ties per mile.

Records furnished for the year 1923 from roads where treatment

work has been carried on systematically for some years show that a number of them have already reached this figure and that some have gone below it.

These records are as follows:

Railroad.	Tie Renewals per Mile.
Atchison, Topeka & Santa Fé	128
Baltimore & Ohio	207
Chicago, Burlington & Quincy	169
Chicago, Milwaukee & St. Paul	225
Chicago, Rock Island & Pacific	140
Cleveland, Cincinnati, Chicago & St. Louis	191
Delaware, Lackawanna & Western	102
Illinois Central	199
Lehigh Valley	91
Michigan Central	206
Missouri, Kansas & Texas	179
Monon	144
New York Central (lines east)	201
New York Central (lines west)	147
Northern Pacific	177
Pennsylvania	202
Union Pacific	195

For the ten-year period ending in 1921, the average annual renewals for the Boston & Maine Railroad were 277 per mile. With a reduction of one-half there would be an annual saving of 139 ties per mile, or approximately \$1,000,000 per year. This point should be reached in from fifteen to twenty years, based on using all treated ties, at the end of about a fifteen year period.

APPENDIX

Description of Processes used for Preservative Treatment of Timber

The principal preservatives now used in this country are zinc chloride and coal-tar creosote, these being used either separately or as a mixture.

Zinc chloride is a metallic salt. The standard specification requires that all zinc chloride shall be acid free and shall not contain more than 0.1 per cent of iron. It also requires that dry zinc chloride shall contain at least 94 per cent soluble zinc chloride, and that in any solution the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required. Zinc chloride is placed on the market in drums of concentrated zinc chloride, or as a 52 per cent solution in tank cars. Zinc chloride is manufactured in the United States and readily obtainable at all times.

Coal-tar creosote is defined as any and all distillate oils boiling between 200 degrees and 400 degrees F., which are obtained from high temperature coal tars by distillation only. Coal tars are obtained by the destructive distillation or partial combustion of

bituminous or semibituminous coals. In commercial practice creosote is to a considerable extent a by-product from the manufacture of other materials. While creosote is produced in this country, the supply has never been equal to the demand, and it has been necessary to import large quantities from abroad, either from England or Germany. During the year 1923, 49 per cent of the total amount used was imported.

Prior to 1907 creosote had been little used in the treatment of ties in this country, the main reason being the question of expense, as with the low cost of both ties and zinc chloride it was felt that the results obtained gave all the economies that were warranted. The principal use of creosote prior to that time was in the treatment of piling for marine work, where it was impracticable to use zinc chloride on account of its solubility in water.

With the increasing cost of ties and the necessity therefore of obtaining longer service life from treated ties, the definite conclusion that creosote was the best preservative, and the establishment in 1909 of standard specifications for creosote by the American Railway Engineering Association, there has followed a gradual increase in its use, so that with the exception of the period during the World War, when the foreign supply was entirely cut off and the available supply in this country appropriated by the government, as a result of which preservative users were forced back to zinc chloride, the use of creosote has gradually increased, and at the present time its use is more than double that of zinc chloride. Of the 53,610,175 ties treated in 1923, 64.8 per cent were with creosote, 28.7 per cent with zinc chloride, and 6.5 per cent with creosote-zinc chloride mixture. Owing to the fact that zinc chloride is unfavorably influenced by leaching in localities of humid atmosphere or fairly heavy rainfall, practically no zinc chloride ties are used in the eastern part of this country.

The methods followed in applying preservative treatment to ties and timber may be classified in three groups:

- (1) *Surface application*, or the coating of the timber with preservative by means of a brush or spray.
- (2) *Open tank treatment*, or the immersion of the timber into preservative in open tanks.
- (3) *Pressure treatment*, or the immersion of the timber in closed tanks or cylinders, with the application of pressure above atmospheric to force the preservative into the wood.

SURFACE APPLICATION

The application of the preservative by means of a brush or spray is, of course, the simplest and cheapest method of treating timber, but it is the least effective. It can be used only with preservative of the oil class and at best gives but a slight penetration. Such a method is confined largely to the butt treatment of poles and posts, and is usually employed only when the quantity of the material to be treated or the location does not warrant the installation of equipment for treatment by a more efficient process.

OPEN TANK TREATMENT

In the open tank treatment several different methods are employed and varying results obtained. The mere dipping of the material into the preservative as practiced in the butt treatment of poles or posts is an improvement over the brush or spray application. A more efficient process consists of a prolonged bath in heated preservative, relying on the absorptive properties of the wood to secure penetration. This method is best adapted to the treatment of small quantities of timber or for use with a preservative that

is corrosive to iron. It is a rather slow process and usually expensive, as the quantity of material treated at one time is small and as the preservative must be kept hot for several hours.

The open tank method that gives the best results employs the pressure of the atmosphere to secure penetration of the preservative. The material is first placed in a bath of hot preservative for several hours. This results in the expansion, and, to some extent, the expulsion of the air and moisture in the wood. The timber is then either left in the preservative, which is gradually cooled, or is transferred to another tank containing cool preservative, or the hot preservative is removed and the tank filled with cool preservative. The cooling of the timber, effected in either way, causes a contraction of the air and moisture remaining in the wood, resulting in the preservative being drawn into the wood in a larger amount and to a greater depth than if the material is simply steeped in hot preservative.

PRESSURE TREATMENT

The pressure process has as its prime objects the distribution of the preservative throughout the wood as uniformly as possible and the securing of an absorption of a sufficient quantity of the preservative to insure the results desired. The essential feature of this method is the use of pressure to force the preservative into the wood. This is accomplished in several ways, the kind of wood, the use for which it is intended, or the kind of preservative used, making it necessary or advantageous to vary the methods employed. The timber is treated in closed retorts or treating cylinders built to withstand a pressure of 250 pounds per square inch, and equipped with steam coils for heating the preservative.

Pressure treatment may be grouped into two classes, as follows:

(a) *Full-cell process*, — the object of which is to fill the intercellular spaces of the wood as completely as possible with preservative.

(b) *Empty-cell process*, — the object of which is, to secure as thorough and deep a penetration as possible with the use of a minimum quantity of preservative.

Full-cell Process. — In the full-cell process the timber is placed in the cylinder and subjected to a vacuum of sufficient intensity and duration to insure that the wood is as dry and free from air as practicable and to permit a retention of the specified amount of preservative. Without breaking the vacuum the retort is then completely filled with the preservative fluid at a temperature of about 175 degrees. The vacuum not only accelerates the entrance of the preservative into the retort, but also makes it possible to force the preservative into the timber more quickly and with less pressure than is the case when the preservative must displace or compress the air in the wood. After the retort is filled additional preservative is forced into the cylinder by means of pressure pumps, the pressure being gradually raised to and maintained at a minimum of 100 pounds per square inch, until the required amount of preservative has been forced into the wood. The pressure is then released, the preservative removed from the cylinder, and, as a rule, another vacuum of not less than 22 inches is drawn, the object of this final vacuum being to remove the surplus preservative from the surface of timbers so that the timber can be removed from the cylinder free of dripping preservative.

In full-cell treatments, using zinc chloride or zinc chloride and creosote mixed, it is usual to steam the timber in the cylinders for not more than two hours, and at no more than 20 pounds' pressure per square inch, before creating the first vacuum.

If the preservative used is creosote, the full-cell treatment is usually called the Bethel process; when zinc chloride is used it is known as the Burnett process and when a mixture of creosote and zinc chloride as the card process.

Empty-cell Process. — In the empty-cell process no preliminary vacuum is employed. There are two empty cell processes, one with initial air, called the Rueping, and one without initial air, called the Lowry. Both of these processes were patented about seventeen years ago.

With the Rueping or initial-air process, the ties in the cylinders are first subjected to an air pressure of sufficient density and duration to provide, under a vacuum, the ejection of surplus preservative and to insure a retention and proper distribution of the stipulated number of pounds of preservative per cubic foot of wood. Then, without change in pressure, the hot preservative is introduced into the cylinder at about 175 degrees. With the cylinder filled the pressure is then raised to a minimum of 150 pounds per square inch, and maintained without loss of temperature until the necessary amount of preservative has been injected into the wood. Then the oil is removed from the cylinder and a vacuum of not less than 22 inches created and maintained until the wood can be removed from the cylinder free from the dripping preservative.

The Lowry process is practically identical, except that no initial air is used and the pressure maintained at a minimum of 100 pounds per square inch after the hot preservative has been introduced into the cylinder.

The results obtained by the empty-cell processes are quite different from that in the full-cell process, the release of the pressure and the removal of the preservative from the retort permitting the expansion of air compressed in the wood, the effect of the final vacuum being to cause further expansion and to some extent expulsion of a portion of the preservative that was forced in during the pressure treatment. The result is a thorough penetration with minimum amount of preservative. The empty-cell process is used almost entirely with creosote and in treating timbers which do not require the complete filling of the interstices of the wood. The cost of such treatment is considerably less than by the full-cell process, as from 40 to 50 per cent less preservative is required.

The specifications of the American Railway Engineering Association provide for three grades of creosote. While grade No. 1 will give the best results, there has always been a scarcity of it and the price is a deterrent against its use in treatment work. At the present time where creosote is being used it is generally a mixture of grade 2 or 3 creosote and refined coal tar, usually on the basis of 80 per cent creosote and 20 per cent coal tar. The practice of adding refined coal tar to creosote was started in 1908. While done principally to reduce the cost, it has been found that an increased permanency has been obtained from the resulting combination after it has been injected into the wood. The result of a good many years' experience in use of creosote shows that after it is injected into the timber a certain percentage evaporates from the wood. These percentages are highest where creosote of low specific gravity is used. The adding of the heavier coal tars to the low-gravity creosotes has increased the permanency of the creosote in the wood, and it has also been demonstrated that there is no risk from an antiseptic standpoint.

The standard recommended practice at the present time for the treatment of ties by pressure process calls for the following amount of preservative per cubic foot of ties:

Zinc chloride — not less than $\frac{1}{2}$ pound dry salt per cubic foot.

Creosote-zinc chloride — not less than 2 pounds of creosote and $\frac{1}{2}$ pound dry salt per cubic foot.

Creosote — not less than 5 pounds per cubic foot with both empty cell processes.

Generally where the Lowry process is used the final retention is 6 pounds, as compared with 5 pounds for the Rueping process.

Practically no ties are now treated with creosote by the full-cell process as it is not felt that this is warranted, as the mechanical life, under present conditions, is much shorter than the life to be expected from the protection against decay given by the full-cell process.

Where timber or piling is treated with creosote and the mechanical wear is absent, the full-cell process with a minimum amount of 10 pounds of creosote per cubic foot is used, and such timbers are undoubtedly giving thirty years or more of service. Where such material is used in coastal waters a minimum amount of 15 pounds per cubic foot is used. At the present time this treatment is the only protection found to be efficient against destruction by Toredos or Limnoria, or by other similar destructive forces.

There has been for some years a divided opinion as to the amount of creosote necessary for protection against decay, some claiming that a less amount will answer if properly retained in the wood and that ties will fail by mechanical wear before failing by decay. On the other hand, some of the wood-preserving experts claim that with the perfection in treating methods and the development of larger tie plates, etc., we are gradually coming to the point where the mechanical wear has been lessened to such an extent that more creosote is necessary to protect the ties against decay and thus give longer service. As a result, some roads are using 7 pounds or more of creosote per cubic foot. We do know that in Europe, where ties are heavily creosoted, a service life of over thirty years is being obtained, but conditions, of course, are not comparable.

EXPERIMENTAL PROCESSES FOR PRESERVATION OF TIES

The history of tie treating in this country shows many experiments, one of the most noteworthy being that of the use of petroleum. Late in the last century the Atchison, Topeka & Santa Fé Railroad began sprinkling their roadbed with petroleum to keep down the dust. One of the results of this appeared to be an increase in the life of the ties after they had been coated with the petroleum oil. As an experiment some test ties were installed in an experimental track in southeastern Texas in 1902, these ties being treated with petroleum only. While petroleum has no antiseptic properties whatever it was found that where, on account of the extreme heat and heavy humidity, untreated ties would last only from two to four years, the petroleum-treated ties gave much longer service, this increase being due not to the prevention of decay, but to the fact that the petroleum regulated the moisture condition of the ties so that they neither shattered nor broomed from the excessive heat or heavy humidity.

Following these results the Atchison, Topeka & Santa Fé Railroad in 1912 installed in their test track at Cleveland, Texas, some 815 ties treated with 1 part creosote to 2 and 3 and 4 parts of petroleum. Up to June, 1924, only 14.3 per cent of these ties had been removed, or were still in the track but not entirely sound, this indicating a fairly long service life to be expected from such a mixture treatment. Satisfied with these results, this road today is treating, for its entire system, all ties with a 50-50 mixture of creosote and petroleum, using 8 pounds to the cubic foot and by the Rueping process.

This is being watched closely and already seven other railroads are using a similar treatment, the percentage of creosote to petroleum varying from 70 per cent creosote and 30 per cent petroleum on one road, to 30 per cent creosote and 70 per cent petroleum on another road. It has been found, especially in the dry, arid countries, that where the treated ties were shattered and broomed from the heat the waterproof coating, resulting from the coating of petroleum, gives the ties treated this way a considerably longer service life than can be obtained from the straight creosote treatment. The same fact has

also been demonstrated on ties placed where there is a very heavy rainfall and humidity, the waterproof coating apparently keeping the moisture out of the ties as well as keeping the preservative in.

A recent inspection of petroleum-treated ties in Hungary, as reported by Mr. C. M. Taylor, Supervisor of the Port Reading Creosoting Plant of the Central New Jersey and Reading Railroads, indicates that ties treated in 1902 with a mixture of 10 per cent creosote and 90 per cent Rumanian petroleum show less than 2 per cent removal at the present time.

A similar test with 295 ties treated with a mixture of petroleum and zinc chloride was started by the Atchison, Topeka & Santa Fé Railroad in 1915, and on June 1, 1924, all these ties were still in the track. While the creosote-petroleum mixture treatment can be made in one operation, it has been necessary to make two operations where the zinc chloride and petroleum mixture is used, as up to the present time no emulsion of the two has been developed that would not break down under pressure in the treating cylinders.

During the past year, however, a process has been developed at the Mellon Institute of Industrial Research at Pittsburgh by means of which zinc chloride and petroleum are injected into the timber in the form of an emulsion made up of zinc chloride solution of 15 to 40 per cent strength and a mixture of heavy asphaltic high-test petroleum thinned to desired viscosity by means of gas oil or petroleum distillate. With this emulsion timber can be treated in a manner quite similar to the methods now used for treatment with creosote. This emulsion differs radically from the emulsions that have been used as wood preservative in the past, in that the zinc chloride solution is dispersed as the internal phase in suitable petroleum medium, while in the former wood preservative emulsions creosote or other oils were dispersed as the internal phase in water or in solutions of water soluble salts.

Experimental treatment of ties is being made by this method and the results to date are quite encouraging, the penetration of the emulsion in the wood being excellent, and the result obtained indicates that the addition of petroleum to the zinc chloride will, under most conditions, add to the service which is obtainable from the use of zinc chloride only.

THE SEWERAGE SYSTEM OF THE TOWN OF WESTERLY, R. I.

BY THOMAS MCKENZIE*

(Presented before the Sanitary Section, January 7, 1925)

THE town of Westerly, located in the southwest corner of Rhode Island, is a complex community of between 10,000 and 11,000 people, covering an area of approximately 20,750 acres, with possibly 1,000 acres covered by the ponds. The town is divided into farming territory, manufacturing villages and beach property. The diversified interests of a community like this have led to further political subdivisions, which in our State are called Fire Districts.

Originally organized and chartered for the purpose of providing adequate facilities for extinguishing fires, their powers have been gradually increased by legislation until now they possess practically all of the powers of the town of which they are a part. Westerly has three such Fire Districts, — the Westerly Fire District, incorporated in 1870; the Watch Hill Fire District, incorporated in 1901; and the Pleasant View Beach Fire District, incorporated in 1915.

The incorporation of these districts was brought about by the desire of the people, not only for the protection of their property from fire, but also for the modern improvements of water supply, lighting, policing, surfaced streets and common sewers.

The Westerly Fire District comprises the compact part of the town and has an area of approximately 750 acres, with a population of about 7,000 people. It is located at the head of navigation on the east side of the Pawcatuck River, about six miles above the ocean at Watch Hill.

The center of the river forms the boundary line between the States of Rhode Island and Connecticut, so that the east half of the river, with its riparian rights, comes under the jurisdiction of Rhode Island, while the west side is controlled by Connecticut. The river affords a natural drainage, or outlet, for the village of Westerly, as well as for several other small manufacturing villages above. Its drainage area at Westerly is about 300 square miles.

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Although the more recent charters granted to the two smaller districts give them the right to construct common sewers, the Westerly Fire District did not have this right. It was therefore necessary for the town to take up the problem, which resulted in much discussion and more or less agitation for nearly thirty years.

PRELIMINARY PLANS FOR SEWERAGE SYSTEM

Preliminary plans and estimates, prepared by Messrs. Shedd, Sarle & Shedd of Providence in 1893, provided for a combined system of sewers, discharging the surface water directly into the Pawcatuck River through several storm-water overflows, with final outlet of sewage also into the Pawcatuck River. The size of the sewers ranged from 6 inches to 62 inches in diameter and the estimated cost was \$193,002.

No action was taken by the town, and the matter was dropped until 1903, when, under the direction of a committee of the town council, another plan was made by the late Samuel M. Gray, C.E., of Providence. By this time the town had provided main storm-water drains, and so the separate system of sewers was recommended by the engineer. The report also recommended that the sewage be disposed of by intermittent filtration, the filter beds to be located about two miles from the town and the sewage to be pumped through a force main on to the beds. This project provided for approximately eleven miles of pipe, which, together with the pumping stations, force main, disposal fields, etc., was estimated to cost \$200,365. While no actual results were obtained, we were making progress. The combined system and the discharge of crude sewage into the river had been abandoned.

This report, however, met the fate of its predecessor, and the taxpayers refused to go on with the project. This was not because of any dissatisfaction with the plans or method of disposal, but because no definite method of payment for the construction and operation of the sewers was presented to the people, and naturally those living outside the compact part of the town objected to being taxed to construct and maintain common sewers for the people living in the village. At the annual financial town meeting held in May, 1904, the committee was discharged, and again the problem of common sewers came to a standstill.

As time went on conditions became worse, new streets were laid out and built up, and the use of water and the demand for modern plumbing increased. In certain sections of the district the soil would not take care of the cesspools, sewage overflowed on to the streets, and while it was pos-

sible for many property owners to secure relief by private pipes leading to the river or to the storm-water drains, there were many whose location prevented even temporary relief, and their only remedy was continual cleaning out of cesspools.

In 1913 the matter was again taken up and referred to the Board of Water Commissioners, with instructions to go into every phase of the conditions and to submit a complete sewerage plan, which, if adopted, would produce satisfactory results at the smallest possible expenditure for construction and operation.

The Board of Water Commissioners submitted their report, together with the report of their consulting engineer, Mr. Samuel M. Gray, in 1916. The widest possible publicity was given to the work of this Board, and a campaign of education was organized and kept up.

The engineers for the Board recommended the adoption of a separate system of sewers, ranging in size from 24 inches to 8 inches and the plans called for 66,902 feet — 12.67 miles. They also recommended the adoption of the Imhoff or Emscher Tank method of sludge removal and treatment of the effluent on sand filter beds. The estimated cost of the system at that time was \$200,000.

FORMATION OF DRAINAGE DISTRICT

Mindful of the fate which befell previous reports, the Board made an exhaustive study of the various ways in which sewerage systems are paid for and maintained. As a result of their studies they recommended that authority be obtained from the General Assembly creating a special drainage district within the town, authorizing the town to provide for the construction and operation, by its Board of Water Commissioners, of a suitable system of public drains and sewers within the drainage district, and providing for the calling of a meeting of the taxpaying voters within the proposed drainage district and the submission to them of the question of approving the provisions of the act and assenting to the assessment and taxes therein provided for, and the obtaining of such assent by vote of such meeting, before the town entered upon the construction of a system of sewers.

This action put the question squarely up to the people who were going to receive the benefits and pay the bill. The resolution was adopted, and the Drainage District, backed by the credit of the town, assumed the burden of the construction and operation of main drains and common sewers.

I have taken some time in describing these preliminary details as it

is one of the chief difficulties in securing public improvements in a small town.

While the engineers were preparing detail plans, specifications, etc., and just as we were about ready to advertise for proposals for the construction of the system, the World War intervened and all work was suspended. All of our engineering assistants entered the service.

CONSTRUCTION STARTED

After the close of the war it was decided to do our bit toward a restoration of normalcy by going on with the work. In May, 1919, proposals



FIG. 1. — MAIN PUMPING STATION

were asked for the construction of about 7.5 miles of sewers, pumping stations, pumps, sewer pipe, manhole frames and covers, etc. The several bids received amounted to \$202,000. No proposals were asked at this time for the force main and disposal plant. Notwithstanding the fact that the bids exceeded the estimates made in 1914 by about 50 per cent, the project had been put off so many times, and there had been so many delays, that the town council and commissioners decided to go on with the work. The contracts were accordingly let, with the exception of the pumping stations, and work was commenced in July, 1919. Later a con-

tract was made with the Briggs Engineering and Construction Company of Providence, on a cost plus a fixed sum basis, for the construction of the substructure of the main pumping station, and this work was started in August, 1919.

Of the total number of feet of sewer contracted for, viz., 40,400 feet, — 11,242 feet were laid by the contractors during that season. It was hoped to continue the work all winter, but the weather conditions were too severe and work was suspended on January 21, 1920, and recommenced April 7, 1920.

Early in May, the demand of the laborers for an increase of 30 per cent in wages being refused by the contractors, we had our first strike. In an effort to connect up the work already done, that the streets might be restored and rebuilt and at least a portion of the system be put in operation, a supplementary agreement was made with the contractors, covering a part of the work, at an increase in prices corresponding to the increased cost of labor, and after nearly four months of negotiations the work was resumed late in August. The labor supply was limited, however, and the entire season's work amounted to only 4,356 feet of pipe sewers. In the meantime, the pumping stations were completed, an outfall pipe laid to the river, and the pumping machinery installed, so we were ready to take care of the sewage, but we had none to take care of.

On December 28, 1920, the contractors again suspended operations until April 28, 1921. Labor troubles immediately followed the resumption of the work, but the difficulties were again patched up and work started. This lasted about two months, and then came another strike. This one lasted about a month and another settlement was made, and from that time, August 10, until December 30, 1921, we had a fairly peaceful period, and succeeded in laying about 11,500 feet of sewer.

In the meantime, discouraged by the progress we were making, and encouraged by some one else's misfortune, to wit, the stone cutters' strike, which had closed up all of the quarries, and made available for the work experienced quarry workers, I recommended to the Board the letting of another contract covering District No. 5, which was not included in the original contract. This was done, and on October 1, 1921, a contract was made with Linberg & Street of Boston for this section. They commenced work immediately, and succeeded in laying about 2,100 feet of sewer before being obliged to stop on account of cold weather.

The town had up to this time expended about \$240,000. The main trunk sewer and lateral sewers, amounting to 27,000 feet, the two pumping stations and the cast-iron outfall were completed, and we had, at

least, a part of a complete sewerage system which could be used, and we looked forward hopefully to 1922. We were again doomed to disappointment as there was no change in the conditions. Upon resuming work another strike took place and this time the contractors decided to bring in outside laborers. This brought about a riot, which, while extremely painful to the contractor, fortunately was not more serious than a few bruises from stones and the loss of a lot of suit cases, thrown into the river. This was the last straw and the contractors positively refused to go on with the work.

A résumé of the work shows that for three years the contractors were unable to work more than one-half of the time, that strikes or threats of strikes, lack of co-operation between the contractors and the laborers and a general spirit of dissatisfaction so permeated the work as to make it almost impossible to secure satisfactory progress or efficient work. At the close of 1921, after three years' work, the contractors had completed $63\frac{1}{2}$ per cent of their contract, and the outlook was not encouraging. In view of these conditions, and after many conferences with the contractors and the Town Council, the Board was authorized to proceed with the unfinished contract and complete the same by day labor. A satisfactory settlement was made with the contractors and the Water Department took up the work.

The contractors for the work in District No. 5 resumed operations after things had quieted down, and the work progressed well. We succeeded in laying about 19,000 feet of sewer, and closed the fourth year of our work with a total of 45,856 feet, or 8.68 miles, of sewer constructed.

SEWAGE DISPOSAL

All of the contracts had either been completed or annulled, the system was in operation, connections were being made, and the Department was free to take up the question of the final disposal of the sewage.

Notwithstanding the fact that the village of Westerly is located on the east side of the Pawcatuck River, which is the natural drainage, and that the easiest and least expensive method of disposal of its sewage would be to discharge it directly into the river, at least until such time as the State authorities compelled them to do something, yet the general sentiment of the people was against this practice, and the engineers were called upon to design a system of disposal.

Before doing this, however, we made some studies of the river and conducted float experiments to determine the velocity and direction of the currents and tidal flow. The drainage area of the Pawcatuck River at

Westerly is about 300 square miles. Many years ago a dam was built across the river for power purposes near the center of the village, about 5 feet above mean low water. This dam has since broken away and has not been rebuilt, so that the tide now rises nearly up to the north end of the village. The average tide is about two feet. A combination of spring tides and south east winds frequently causes a rise of five or six feet.

There are no available records of flow in the Pawcatuck River at Westerly, but by estimating its flow on the basis of the Sudbury River

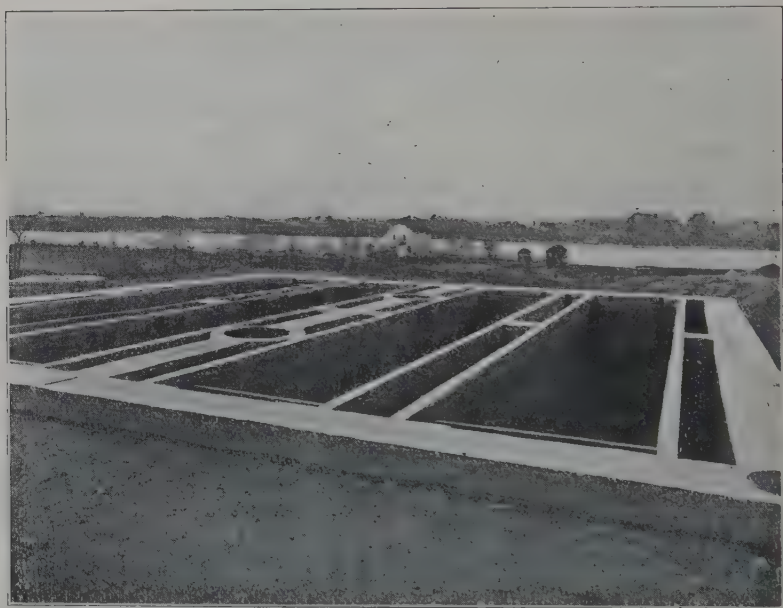


FIG. 2. — IMHOFF TANK

watershed in Massachusetts, the average yearly discharge at the site of the last dam would be 464 cubic feet per second; for the driest six months, 178.5 cubic feet per second; and for the driest month in the year (July), the average flow would be 71.6 cubic feet per second, and it is safe to assume there are probably times when the flow for short periods would not exceed 60 cubic feet per second. From the dam to Beach Street the river is about 150 feet wide and from Beach Street to Clark's Thread Mill 300 feet wide, with a channel of 100 feet in the middle. On either side of the channel the water is very shallow and sometimes bare at extreme low water.

Float experiments made in the river show that where floating matter is placed on the surface in the channel above the Clark Thread Mill it drifts over and grounds on the mudflats west of the channel, even on flood tide, showing conclusively that, owing to the low velocity of tidal currents, the wind will carry floating particles in an opposite direction, landing them in shallow water.

A cross-section of the river taken about 1,400 feet above the Clark Thread Mill Dock shows an area of 678 square feet between mean high and low water, or 2 feet in depth. Between the line where the cross-section was taken and the lower dam, the river covers an area of 28 acres, and at 2 feet in depth contains 2,439,360 cubic feet of water. As it takes about six hours from high to low water, the current velocity is reduced on an average to about two inches per second. There are 113 cubic feet per second passing this cross-section plus what fresh water may be flowing in the river at the time. On the flood tide the velocity would be less, owing to the river flow in the opposite direction. With this extremely low velocity in the river, sedimentation would take place rapidly and floating matter on the ebb tide would not be carried more than 3,600 feet before it would be brought back by the flood tide.

Messrs. Metcalf & Eddy in their publication "American Sewerage Practice" state that from statistics compiled from the census of 1910, "Out of a total population of about 91,600,000 in the United States, about 34,700,000, or 38 per cent, live in places provided with sewerage systems. Of these systems, those serving a population of 3,900,000, or 11 per cent, were provided with sewage-treatment works. The sewage of 89 per cent of this population in sewered places was discharged untreated into water."

The tendency of modern sanitation is toward greater restriction in the discharge of untreated sewage into rivers or even tidal waters, such as the Pawcatuck River, but I believe that with so large a body of water as the Pawcatuck River for the final disposal of the sewage, the refinements of purification are not absolutely required.

Our main object was to dispose of the sewage without having offensive conditions or a menace to health. In accomplishing this we were also mindful of the fact that, in our endeavors to so treat the sewage as not to pollute the waters of the river, great care must be taken that the process or treatment would not in itself become a nuisance to the community.

Our consulting engineer, Mr. Gray, recommended the adoption of the Imhoff Tank, with a further purification of the effluent through filter beds. The town had already purchased about 10 acres of land located on the river and admirably adapted for a sewage-disposal plant.

Following the death of Mr. Gray, which occurred before the final adoption of the disposal plans, the work was taken up by his principal assistant, Mr. George H. Leland, who prepared the final plans and has acted as consulting engineer. As a preliminary study of the problem we had a pattern maker build a wooden model to a scale of one-eighth the size of the proposed Imhoff Tank. This model was set up in our workshop, and we gathered around it and discussed the various conditions which might arise, and undoubtedly many which would never happen. I spent many hours hanging over that model, trying to visualize actual conditions. As I remember it, the cost of the model was about \$200, but it was money well spent. I have now taken it apart and salvaged the lumber, for fear some one might see it and think we actually did build the tank like it. We did not, for we found many things that could be improved.

DESIGN OF IMHOFF TANK

In the final design the tank is a double rectangular tank, 46 feet square inside with four sedimentation chambers 8 feet by 46 feet and 15.5 feet deep to the top of the sludge compartment. In the middle partition wall there are two manholes for the sludge pipes and gates. The main sludge carrier runs through this partition wall. The discharge into each compartment is controlled by sluice gates and the outfall by stop planks at either end. It is possible by these gates and stop planks to regulate and control the flow of sewage in any way that may be desired. The effluent is discharged on to the filter beds through a 15-inch pipe leading into a distributing manhole, and from this manhole the effluent is discharged into the river or distributed on to the filter beds. There is also a 16-inch pipe leading from the force main to this distributing manhole, controlled by a 16-inch gate, by means of which the tank may be cut out and the raw sewage discharged from the pumps directly on to the beds, or directly into the river. We are, therefore, in a position to work any kind of combination which may be required.

The Imhoff Tank is designed to care for the sewage from a population of 8,000 people. The detention period is about two hours. The sludge compartments are based on 1.5 cubic yards per 1,000,000 gallons of sewage.

An interesting feature of the construction of the Imhoff Tank was the precasting of the concrete partition walls in the sedimentation chambers. These walls are 2 inches thick and were cast in moulds outside of the work, picked up in slings and set in place with the derrick. On the lower sloping section, 4-inch by 6-inch brackets were cast, spaced 4 feet 10

inches center to center, on which the section rested on the main beam. These sections were 11 feet 8 inches long, four sections for each compartment, and were reinforced with $\frac{5}{8}$ inch and $\frac{3}{8}$ inch bars and expanded metal.

The lower vertical section slabs were divided into two parts, each slab being 2 feet 6 inches wide, 2 inches thick and 23 feet 6 inches long. These slabs were also cast in moulds on the ground. There were thirty-two of these sections, each section reinforced with $\frac{1}{2}$ inch rods and expanded metal. The upper vertical slabs being 6 inches thick on top, forms were built on the lower slab and the concrete poured in place. The casting and handling of these thin slabs being somewhat of an experiment, we were skeptical of the result; but after one or two trials we found it could be done successfully and the result was a smooth surface on the partition walls, — a most desirable feature of Imhoff Tank construction.

This tank has been in operation since January 20, 1924, and during that time 135,000,000 gallons of sewage have passed through it. The settling solids have found their way into the sludge compartment without assistance, and there has been no necessity for "squeegeeing" the sloping walls of the sedimentation compartment. The surface of the tank has been free from floating masses of solids and there has been no foaming in the gas vents at any time.

FILTER BEDS

Two filter beds of approximately one acre each have been constructed. These beds are designed to work at a rate of 200,000 gallons per day. It is hoped, however, to increase this rate, as at the present time the sewage is highly diluted with ground water. The final plans for a population of 8,000 people call for five acres of sand filters.

PUMPING STATIONS

There are two pumping stations, the main station on lower Margin Street, where all the sewage is collected and pumped into the Imhoff Tank, and the Canal Street station for District No. 1 located north of the railroad. This district has an area of about 70 acres and is too low to flow by gravity into the main system.

The Canal Street station is built of concrete, with a brick superstructure 10 feet square in which are located two 8-inch vertical De Laval pumps with a capacity of 600 gallons per minute, each operated by two 10 horsepower motors controlled by float switches. The pump chamber is 17.50 feet below the surface.

The screen chamber is 10 feet square with a deck roof, and is fitted with bar screens and slots for secondary screening if necessary. The capacity of the screen chamber is about 3,000 gallons. The total lift into the main sewer in Canal Street is 20 feet.

The substructure was built in the winter of 1921 by Fred D. Miller & Co. of Norwich, Conn. The contract price was \$6,400. The superstruc-



FIG. 3. — MOTOR ROOM — MAIN PUMPING STATION

ture was built in the spring of 1922 by R. A. Sherman Sons Company. The contract price was \$1,120, making the total cost of the station \$7,520. We had no particular difficulties in building this station, and the work was tight. The station has been in operation for two years and has required very little attention.

As stated before, the contract for the substructure of the main pumping station was given to the Briggs Engineering and Construction Company on a cost plus a fixed sum basis, and the work was started in August, 1919.

The main building is 27 feet square, the substructure including the

part covered by the building, and the deck roof is 50 feet by 36 feet. The pump chamber and sewage chamber are 9.25 feet below mean low water.

The sewage enters the screen chamber at elevation *minus* 4.87. A concrete partition, fitted with stop planks, divides the grit chamber into two compartments for the purpose of cleaning. There are also channel irons set in the concrete for secondary screens, to be used while the bar screens are being cleaned. We have not used these secondary screens yet, and perhaps will not have to for some time.

In addition to the screen chamber under the deck there are two rooms designed for an incinerator and coal rooms. The pumps are located in the pump room, separated from the sewage chamber by a concrete wall. On both sides of this partition wall are the stairs leading down into the screen chamber on one side and to the pump chamber on the other side. Considerable difficulty with water was encountered in building this superstructure, and on two occasions the work was entirely submerged by exceptionally high tides. We had a very efficient pumping plant, sufficient to keep the water down under ordinary conditions, but it was useless, of course, to attempt pumping out the Pawcatuck River, so the only thing we could do was to wait for the tide to fall. The excavating was done with a derrick and buckets, and the boiler used on the hoisting engine furnished steam for the pumps.

Cost of the substructure	.	.	.	.	.	.	\$24,630
Cost of the superstructure	.	.	.	.	.	.	6,800
Total cost	.	.	.	.	.	.	\$31,430

The machinery in the main pumping station consists of two De Laval 8-inch vertical centrifugal pumps with a capacity of 1,250 gallons per minute each, direct connected to two 25 horsepower Westinghouse electric motors with Westinghouse automatic controllers and float switches.

The power is furnished by the Westerly Light and Power Company, and the station is automatic in operation, except in case of low voltage, or shutting off of the current, either one of which automatically throws out the main switch and this has to be put in by hand. We have this trouble only in times of heavy storms. The station has been in operation for about two years and has given very satisfactory service.

A 16-inch Venturi meter tube is placed in the force main with register-indicator-recorder in the motor room. The present flow of sewage as measured with the Venturi meter ranges from 300,000 minimum to 400,000 maximum gallons per day. The daily average for the year 1924

was 368,000 gallons. The power cost for 1924 was \$8.17 per million gallons. The total head from the pumps to the tank is 31.5 feet, making the power cost approximately 26 cents per million gallons raised one foot.

A large amount of ground water and infiltration from the river was encountered in constructing the main sewers, especially on Main Street parallel to the river. The 24-inch sewer on this street is below the river level, and the soil is coarse sand and gravel.



FIG. 4. — PUMP ROOM — MAIN PUMPING STATION

The joints were made with G. K. joint compound and it proved so successful that we have continued its use on the entire system. The man-holes are all of concrete, wooden forms being used.

The total flow of ground water varies from 275,000 to 300,000 per day and averages 30,000 gallons per mile of sewer per day, or, on a basis of 500 acres (the present area sewered) of 600 gallons per acre per day. Our consulting engineer estimated the ground water at about 60,000 gallons per mile of sewer, or 1,000 gallons per acre per day, so we feel that, considering all the difficulties we had with ground water, the leakage is not excessive, and has justified the use of joint compound for all joints in the pipe sewers.

Cost of the Imhoff Tank	\$26,564 58
Cost of the 16-inch force main	10,090 16
Cost of the filter beds	23,843 87
Total cost of disposal plant	\$60,498 61

The total amount expended on the system to date is approximately \$510,000.

Although the sewerage system of Westerly presents no unusual or untried features, it does represent the earnest efforts of the officials and people of the town to care for the sewage of their community without injury to person or property, in spite of soaring prices, strikes and unforeseen difficulties. The future success of their efforts will not be due entirely to the careful design and construction of the plant. Cleanliness, constant vigilance and intelligent supervision must follow the designer and constructor to insure the results for which we are all striving.

OVERCOMING ICE DIFFICULTIES AT THE HOLTWOOD POWER PLANT

By H. W. Lowy *

THE Holtwood plant of the Pennsylvania Water and Power Company is located on the Susquehanna River 23 miles above tide water. The drainage area of the river at Holtwood is 26,000 square miles. The total hydro-turbine installation comprises 150,000 h.p. in 10 units and 2 1,000-h.p. turbine-driven exciters.

The ice troubles encountered at the power plant are of three sources or origin: (1) river ice, (2) forebay ice, and (3) frazil ice.

(1) *River Ice*. — Yearly ice floods of great volume occur in the Susquehanna River, which often cause flooding of lands adjoining the course of the river in localities where sand bars, rocks, islands or contractions of the river valley afford opportunities for grounding of the ice. Ice accumulates in large gorges which impede the flow of the water for a time and break up after sufficient water has accumulated to move these ice barriers. Such ice runs are very spectacular but quite harmless, since the ice is prevented from entering the gatehouse by the structures surrounding the forebay.

The forebay proper is enclosed by a stone fill ramp, three booms floating between piers and a skimmer wall with submerged arches. The general trend of the main river current during high water is toward the west shore, carrying the greater quantity of ice away from the power house. Instances of ice from the river proper entering the forebay are very few and were caused by the floating booms freezing into the slots of piers in which they move. The only precaution which has to be taken with this outside equipment is to keep the slots free from ice by chipping the booms clear as a matter of upkeep routine.

The more serious trouble accompanying ice runs is the trash which is dislodged from the shores by the action of the ice and carried downstream. Trees, logs, railroad ties, boards and stumps are carried along, but the smaller débris, such as roots of bushes, reeds and grass, small twigs and leaves, is what causes the clogging of the intake screens. These screens have to be cleaned of such matter by the use of a large rake oper-

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ated by the gatehouse crane. At times screens are so badly obstructed that the output of the turbines is materially reduced, making it necessary to remove the clogged screens for cleaning. This is generally done by closing one head gate of the affected unit and lifting the screens out on the gatehouse floor, where the obstructing mats of intertwined roots and leaves are raked off. It is generally sufficient to keep well ahead of the accumulation of trash by the employment of the rake.

(2) *Forebay Ice.* — The sheet ice which originates within the forebay proper is troublesome at times. Ice cakes become dislodged by the load



FIG. 1.— STEAM PLANT AND POWER HOUSE

fluctuations to which the water surface is subject, especially when low forebay elevations are reached, and are carried against the forebay screens, whence they are removed by means of the rake. To minimize the breaking up of this ice sheet a number of log booms, consisting of telephone posts, are linked together, floated into the forebay and anchored to the shores at both ends, allowing plenty of slack for rise and fall. The sheet ice so confined usually remains within these booms from the first freezing to the end of the cold season.

(3) *Frazil Ice.* — Frazil and anchor ice is the third kind of ice trouble to guard against and is of a more insidious nature. Some precautions can

be taken to avoid these difficulties by the proper design of the plant and equipment, but the most reliable protection lies in a systematic procedure for detecting the approaching danger well in advance and of mitigating its disturbing effects by well-organized effort.

There are many possible ways to diagnose impending frazil ice runs, the first being by observation of meteorological conditions. The contributing factors giving rise to the formation of frazil ice are the follow-



FIG. 2.—VIEW OF RIVER DURING ICE RUN

ing: (1) low air temperatures, (2) low water temperature, (3) high wind or strong currents, (4) open water in the vicinity of the plant.

During the winter season frazil ice may be expected as long as the storage pond remains totally or partially without a protective sheet of ice. At such times, especially with the advent of cold waves, frazil ice troubles occur at the plant.

The effect of frazil ice on operation consists mainly in the clogging of the intake screens and turbine passages and the consequent reduction of the load carrying capacity of the units. Auxiliary equipment, such as exciters and pumps, are also affected.

DIAGNOSING IMPENDING FRAZIL ICE

Temperature observations of air and water, normally made hourly throughout the year, are taken every half hour when the general conditions appear favorable for the formation of frazil ice.

The intake screens, which are placed in stacks of five in each of the four intakes of each unit, are hoisted up to leave only the lower two screens at the bottom of each intake as soon as the water temperature reaches 3° C. Of course there is some danger of floating débris entering



FIG. 3.—ICE TAKEN FROM SCREENS IN GATEHOUSE

the turbines; however, the periodical inspection of all racks by divers and the removal of all submerged logs, etc., provides a fairly sufficient safeguard against such occurrences.

Test chains, consisting of a 6-foot length of iron chain fastened to a 3-inch rope, are placed in the gatehouse. These chains, which are suspended in front of the intake screens, are fastened to the rope in such a manner as to leave about 6 inches of the rope overhanging the chain. This part of the rope is frayed so that frazil ice will adhere to the rope

first. In every instance it has been found that the frazil ice will adhere to the frayed part of the rope before collecting on the chain. These chains are lifted up and weighed every half hour and the ice cleaned off after the first indication is found on the frayed rope.

The action of the turbine-driven 50 h.p. hand control pump furnishes one of the first indications of the formation of frazil ice. This pump is operated at a fixed gate opening and its speed observed constantly. Its intake pipe is covered with a closely spaced screen which clogs very

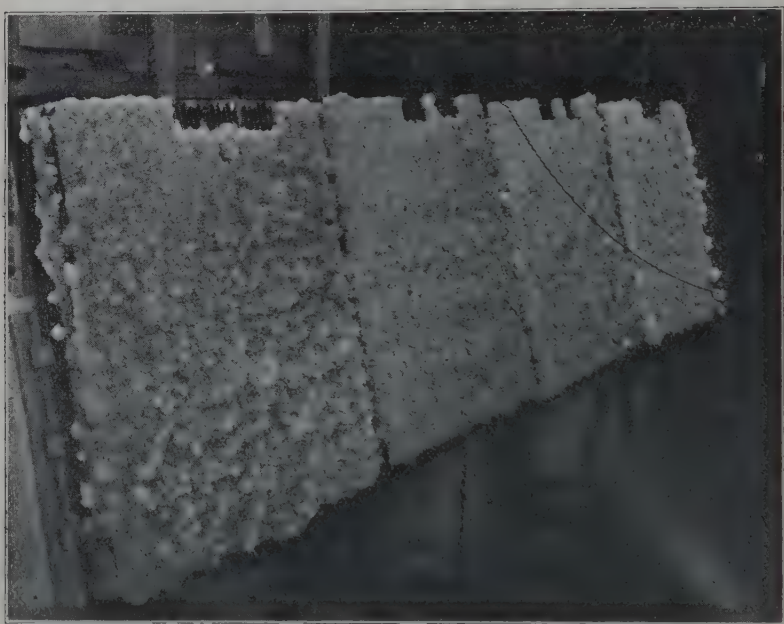


FIG. 4.—ACCUMULATION OF FRAZIL ICE ON BOTTOM SCREENS

View taken during ice run, of January 6, 1925

readily with ice, so that the decreased speed of the pump is a sure sign of imminent ice trouble. This clogging of the inlet of the intake frequently takes place in advance of the indications of ice on the test chains and is often accompanied by rumbling noises in the penstock.

The equipment for steaming the turbine pits is kept under steam continually as soon as this ice is expected. In addition to a stationary boiler two dinkey engines are also kept in readiness for immediate connection with the steam lines leading to the wheel pit.

The arrangement with the Customer's steam generating stations consists in giving a four-hour notice of the expectation of a frazil ice run. This arrangement provides for augmenting the boiler reserve to a sufficient extent to allow for taking two units out of service at the Holtwood plant, — one held for a reserve and the other used for heating of wheel pits. In other words, the steam stations must be prepared to pick up an additional block of 26,000 kw. whenever the actual reduction of generating capacity takes place due to this cause. This warning is cancelled at the cessation of the frazil ice run. Naturally a number of ice warnings are given which are not followed by an actual ice run and these result in the steam stations preparing for the possible load reductions.

HANDLING OF EQUIPMENT DURING A FRAZIL ICE RUN

After the presence of this ice has been detected, either on the chain or at the pump, the gate-operating mechanism of the turbines is kept in motion, preventing ice from freezing to the mechanism. The gages indicating pit pressure are watched for indications of air entering into the wheel pit, since the admission of cold air accelerates the forming of frazil ice.

The load capacity of each turbine is determined by bringing the unit up to full gate opening and then reducing the load in sequence until the full capacity of all units is obtained. From a curve showing the normal capacities of the individual units any reductions of the full capacity at that hydraulic head may be noted at once.

As soon as the output of any unit is appreciably reduced it is taken out of service and replaced by the reserve unit.

Steaming of Pits. — All turbine units are supplied with steam lines of 1-inch diameter leading from the steam boilers directly into the pits. Each unit which shows decrease in output is taken off the main bus, the headgates are lowered, the pit drained and live steam admitted for twenty to thirty minutes, which is generally sufficient to free the ice from the metal surfaces. It breaks off easily when water is again admitted to the pit and is floated out by the current of the inflowing water. During this interval the load has been carried by the reserve unit. Each machine is taken out of service and treated the same way until normal capacity is reached again.

Exciters. — There are two turbine-driven and one motor-driven exciters in service. At times of ice trouble the motor-driven exciter is loaded to capacity, so that one of the water-driven exciters carries the balance of the load. The other water-driven exciter is kept in reserve

up to the time when clogging by frazil ice occurs on the turbine-driven exciter. The latter is taken out of service for steaming and the reserve exciter used.

All direct current auxiliaries are transferred to the alternating current outfit as far as practicable.

Organization. — The power house crew, including the maintenance force, are assigned to their duties in connection with the observations and methods of operating during the frazil ice run. Special instructions assign to each man his individual duty.

OCURRENCE OF FRAZIL ICE TROUBLES

The number of frazil ice troubles occurring during the years 1919 to January 6, 1924, which caused actual reduction of capacity are listed in the accompanying table. However, in addition to the ten instances recorded there were eleven ice warnings issued which demanded mobilization of forces at the hydro plant and at the steam generating station but which did not result in power reduction. This is an operating loss which cannot be entirely avoided yet can be materially reduced by better observations and by the exercise of good judgment on the part of those responsible for the operation of the plant.

A chart* has been prepared showing a graphical representation of an ice run lasting, with intervals, over a period of three days. This diagram shows air and water temperatures, the time of warning given to the steam station of the expectation of frazil ice, the weights of iron on the test chain and the reduced speeds on the hand-control pump, the number of units steamed, the normal station capacity, the reduction due to frazil ice and the station load actually carried.

CONCLUSION

The methods described above were evolved by the organization at the Pennsylvania Water and Power Company. The credit for the understanding of the phenomena of frazil ice and anchor ice must be given to Professor Barnes of McGill University, whose classic book on the formation of ice was the inspiration of the power plant engineers in their efforts to secure uninterrupted service at Holtwood.

* Although it was not practicable to reproduce this chart on account of the expense, it may be seen at the library of the Boston Society of Civil Engineers, 715 Tremont Temple, Boston, Mass.

POWER REDUCTION DUE TO FRAZIL ICE, 1919-1924

DATE	"Four-hour Warning" issued"	First Indication of "Ice Running"	"Test Pump" stopped	"FIRST MEASURED "CAPACITY REDUCTION"		TIME INTERVAL†		MAXIMUM REDUCTION	
				Time	Kw.	Hrs.	Min.	Time	Kw.
Jan. 5, 1919	—	5.40 A.M. (chain)	5.45 A.M.	8.18 A.M.	1,000	2	38	8.18 A.M.	1,000
Dec. 16, 1919	—	7.16 A.M. (chain)	7.57 A.M.	8.30 A.M.	1,000	1	14	8.30 A.M.	1,000
Jan. 18, 1921	—	1.51 A.M. (pump)	2.18 A.M.	4.26 A.M.	2,000	2	35	8.00 A.M.	6,000
Jan. 25, 1921	—	12.25 A.M. (chain)	12.42 A.M.	2.45 A.M.	8,000	2	20	6.40 A.M.	20,000
Jan. 26, 1921	—	1.00 A.M. (pump)	1.00 A.M.	2.57 A.M.	10,000	1	57	6.15 A.M.	20,000
Dec. 25, 1921	—	10.20 P.M. (rope)	11.42 P.M.	1.00 A.M.	3,000	2	40	7.10 A.M.	12,000
Dec. 29, 1921	—	7.11 P.M. (rope)	7.38 P.M.	8.33 P.M.	8,000	1	22	10.00 P.M.	26,000
Jan. 1, 1922	12.14 P.M.	5.37 P.M. (pump)	6.18 P.M.	7.00 P.M.	12,000†	1	23	6.30 A.M.	24,000
Jan. 13, 1923	1.14 A.M.	2.40 A.M. (pump)	2.40 A.M.	5.35 A.M.	6,800	2	55	8.15 A.M.	17,100
Jan. 6, 1924	8.45 P.M.	2.30 A.M. (rope)	2.53 A.M.	4.14 A.M.	16,900	1	44	7.55 A.M.	22,000

* Ice on rope or chain, or speed reduction of "test pump." During this period eleven additional warnings were issued but did not result in any capacity reduction. The station capacity of the plant for the period listed was 72,000 kw. at Elev. 165.0.

† Time interval between first indication of "ice running" and first measured "capacity reduction."

‡ Frequency low 7.15 P.M. caused by insufficient steam capacity at steam generating plant.

OF GENERAL INTEREST

PRESIDENT COOLIDGE SIGNS TEMPLE BILL

Topographic Mapping of United States to be Completed

On February 27 the President signed the Temple Bill, which provides for the completion of the topographical survey of the United States within a period of twenty years from the date of its passage. This bill is of great importance to the engineers of this country as it establishes as a definite government project "a general topographical survey of the territory of the United States, including adequate horizontal and vertical control, and the securing of such topographic and hydrographic data as may be required for this purpose, and the preparation and publication of the resulting maps and data." The provision that this work be completed within twenty years will result in the mapping going forward at a speed far greater than has been possible under former conditions.

The engineering societies throughout the United States have been active supporters of this bill. The Council of the Affiliated Technical Societies of Boston adopted resolutions last spring favoring this bill and urging the members of Congress from Massachusetts to support it. Although not an engineer, Congressman Temple, the author of the bill, became convinced of the value of this mapping program and has worked indefatigably in behalf of the project. To him belongs much of the credit for the adoption of this bill by Congress.

The bill as originally presented a year ago provided for the authorization of \$950,000 for this work during the year ending June 30, 1925, but due to its not being enacted until the past month the date was changed to June 30, 1926. Although no appropriation was made by Congress, under the authorization carried by this bill, it is probable that when Congress assembles next winter a deficiency appropriation will be made to take care of the latter part of the fiscal year beginning June 30, 1925. Thereafter, subject to the action of the Appropriations Committee and the Budget Officer, it is expected that annual appropriations will be made in sufficient amounts to carry out the provision that this work be completed within twenty years.

Little has been printed in the daily press concerning this bill owing to its lack of so-called "news value" compared with Teapot Domes, investigations, Congressional salary boosts and the like, but for constructive legislation which will aid in the development of natural resources and will further the interests of commerce and industry, the enactment of the Temple Bill is one of the few real accomplishments of the 2d session of the 68th Congress.

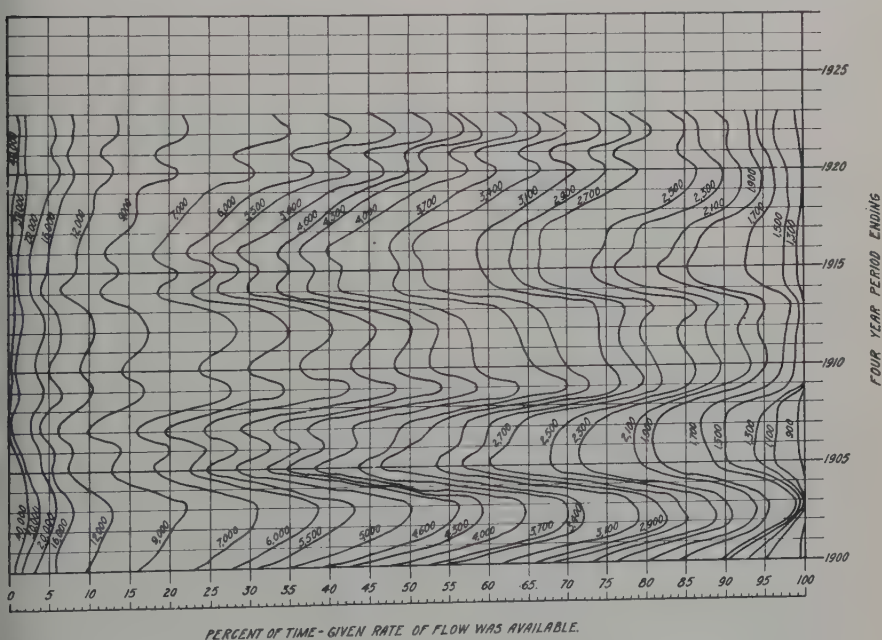
Cycles of Run-off and Future Trends

By Dana M. Wood, with Stone & Webster, Inc.,
Boston

Analogy to Rainfall. — Run-off is the direct result of precipitation, and therefore major variations in the latter directly influence the former. Engineers have developed several different methods of studying rainfall cycles, and because of

extensive calculations required and to the fact that run-off records are available for much shorter periods of time than in the case of rainfall.

Methods of Study. — As illustrative of one method of analysis, see Fig. 8, "Report of the Committee on Run-off", JOURNAL of Boston Society of Civil Engineers, October, 1922. The objection to this method is that different conclusions can be reached if a different number of years are averaged, and prob-



the close relation between precipitation and run-off similar methods may be applied to a study of run-off. Run-off in "depth in inches" for each month may readily be used for such studies. Little has ever been attempted along these lines, however, probably due to the

ably the proper number to include in each period will vary for different gaging stations and perhaps even for the same station.

Another and new method suggested by Mr. S. H. Smith of Stone & Webster, Inc., and developed by the writer, is

illustrated by the accompanying diagram, in which trends are studied by successive four-year averages of yearly duration curves, and which might well be called a contour map of run-off for the specified station. Theoretically, such a diagram should be worked out first for individual years, then two-year, three-year, four-year, etc., averages, until a period of time is found that will eliminate minor variations and show general smooth trends. Practically, on account of the labor involved in such a procedure, the length of period can be chosen by inspection of the basic data, which will result in sufficiently smooth curves to enable broad conclusions to be drawn. The best length of period will not necessarily be the same for all gaging stations, but undoubtedly some particular term of years should be chosen for purposes of comparisons between stations.

In the illustration presented the studies were not carried out to the extent of determining the best number of years to average. The broad conclusions were reached, however, that the chart as presented indicates (1) that for the period of records as a whole, from a power production viewpoint, there has been a general gradual improvement in run-off; and (2) that during the five years following 1923, a decided decrease in the run-off may be expected, the minimum to be reached in 1925 or 1926, and to be followed by another period of improving run-off.

Beverly to get Cast-Iron Pipe from French Foundry

The Committee on Public Service and Aid of Beverly, Massachusetts, awarded a contract on February 24 to B. Nicoll & Company, a French concern, for supplying 168 tons of bell and spigot cast-

iron water pipe. The price was \$51.75 per net ton for 6-inch and \$50.75 for 12-inch pipe, F.O.B. cars, Beverly, for delivery in six to seven weeks. Four American firms bid on this order, their prices being from \$54.80 to \$56.10 per ton. The pipe quoted on was Class "B" cast-iron pipe, to conform to the standard specifications of the American Water Works Association. The price includes the cost of inspection at the foundry at Pont-a-Mousson, France.

Another instance of the entrance of foreign pipe into this market was the recent purchase by Stone & Webster, Inc., of 800 tons of gas pipe made in France. Although this pipe has not yet been put in service it has been carefully inspected and appears to be perfectly satisfactory.

Curb Heights and Automobiles

Automobiles and high-speed roadway traffic may introduce into highway design one revolution not yet generally recognized, namely, the "high curb." Formerly a curb six inches high was a usual standard. Such a curb makes a comfortable step both down and up; the purpose was to make it easy for pedestrians to cross a roadway at any point they pleased, in other words to facilitate "jay walking". Nowadays there is a growing purpose to keep pedestrians off roadways except at specified crossings; also, particularly on bridges, to give the sidewalks protection against automobiles running wild. Consequently, we may soon see the standard curb height raised to twelve inches, or even to half the diameter of a balloon-tired wheel! Curbs nine to twelve inches high are used on several recent bridges. Witness the curb laid on Harvard Bridge across the Charles River Basin during the repairs just completed; this curb rises

not only twelve inches above the roadway but six or eight inches above the sidewalk. It is today generally commended, yet think what criticism it would have aroused only a few years ago, especially as affecting pre-prohibition pedestrians!

Contracts for State Highway Construction

Contracts amounting to \$646,000 for resurfacing and reconstruction of highways have already been let by the Massachusetts Department of Public Works, Division of Highways. None of these jobs have started as yet, but the bids were received during the winter in order to permit contractors to get their organization and equipment together for an early start in the spring. Other jobs will be advertised very soon. The résumé which follows gives the location, type of construction, name of low bidder and the price bid.

On December 23, bids were received on three projects, as follows:

(1) Framingham-Ashland-Holliston, on the road from Framingham to Milford, approximately 4 miles of state highway to be resurfaced with bituminous macadam; the Lane Construction Company of Meriden, Connecticut, low bidder, price \$88,599.

(2) Fairhaven-Mattapoisett, on the road from New Bedford to Wareham, $3\frac{1}{4}$ miles of state highway to be reconstructed with bituminous macadam; the New Haven Construction Company of New Haven, Connecticut, low bidder, price \$128,303.

(3) Whitman, on the road from Weymouth to Bridgewater, about $\frac{1}{2}$ mile of state highway to be resurfaced, together with an extensive drainage system; Powers Brothers of Brockton, low bidder, price \$15,347.

On December 30, bids were opened for the reconstruction of 4 miles of state highway in Fitchburg and Westminster, bituminous macadam, on the road from Fitchburg to Greenfield; Carlo Bianchi of Framingham, low bidder, price \$211,824.

On January 27, bids were opened for the reconstruction of about $3\frac{1}{3}$ miles of state highway in Lee-Lenox, on the road from Springfield to Pittsfield, cement concrete; L. C. Carchia of West Roxbury, low bidder, price \$202,000.

Temperatures in Reinforced Concrete Chimney Shells

The following is a résumé of an article by E. A. Dockstader, of Stone & Webster, Inc., which was presented on Feb. 27, 1925, at the annual convention of the American Concrete Institute, in whose Proceedings the detailed paper will appear.

Reinforced concrete chimneys have been in use in this country for about twenty-five years. With the growth of central power stations, large reinforced concrete chimneys have become increasingly common. This type of construction has many features in its favor, particularly for chimneys superimposed on the power station structure where the lighter weight of a reinforced concrete chimney as compared with a brick chimney is important. Cracks, which have appeared in a number of reinforced concrete chimneys, have led to some doubt on the part of engineers as to whether such construction is reliable. Such cracks can usually be traced to improper design, faulty workmanship or a combination of the two. It was with a view toward improving the design of these structures that the tests under discussion were made.

Theoretical analyses of the stresses in chimney shells due to the weight of the

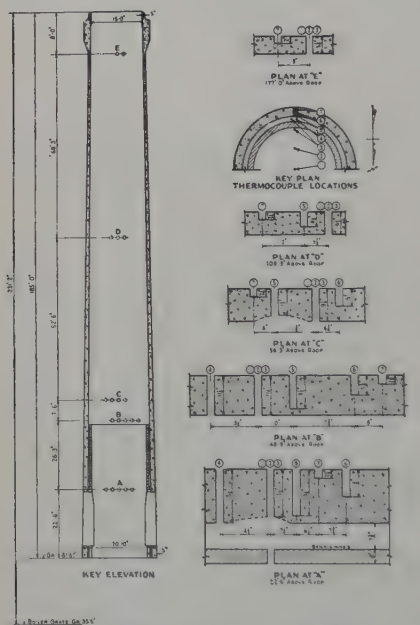
chimney and the force of the wind upon it are available. Wind velocities have been measured for many years with more or less accuracy and records kept of maximum conditions. It has, therefore, been possible to proceed with reasonable accuracy in designing reinforced concrete chimneys to resist the stresses due to dead load and wind, and for many years the emphasis in the design of chimneys has been placed on the

ference in temperature in the concrete between the inner and outer faces of the chimney shell in order to use the formulas resulting from theoretical analyses. This indeterminate factor has prevented the application of these formulas to the design of reinforced concrete chimneys with any degree of assurance.

During the summer of 1922 it was suggested by the Heine Chimney Company of Chicago, Illinois, that provision be made in the construction of a chimney which they were about to erect for the New Bedford Gas and Edison Light Company, under the direction of Stone & Webster, Inc., so that tests could be made when the chimney was in service to determine the temperatures in the concrete of the chimney shell. The New Bedford Gas and Edison Light Company were not only willing that the tests should be made, but during their progress co-operated in every way and rendered much valuable assistance. The actual tests were planned and carried out by Stone & Webster, Inc.

The chimney selected for test was erected in the fall of 1922. It is 15 feet internal diameter at the top and 188 feet high above its foundation, which is superimposed on the steel framing of the power station above the boilers. The chimney is lined with common brick to a point approximately 2 feet below level "B", in the accompanying sketch. This lining is 8 inches thick to a point approximately 6 inches below level "A", and 4 inches thick above this point, with an air space between the brick lining and the concrete shell, this air space being sealed at the top of the brick lining.

When the chimney was constructed brass sleeves were cast in the chimney shell at various levels as shown. It was the intention to arrange these sleeves so that at each level the temperatures could be measured (1) of the gases at the center of the chimney, (2) of the gases midway between the center and



DETAIL OF CHIMNEY, SLEEVES AND THERMOCOUPLE LOCATIONS

proper proportions of shell thickness and reinforcement to resist these stresses.

It has long been recognized that the stresses in the chimney shell due to temperature were of great importance, and theoretical analyses of these stresses, both circumferential and vertical, have been developed. The actual temperatures in the concrete of the chimney shell under operating conditions have not heretofore been measured. It has been necessary, therefore, to assume the dif-

the chimney shell, (3) of the gases immediately adjacent to the chimney shell, (4) of the air (where the chimney was lined) between the lining and the concrete, (5) of the concrete approximately 2 inches from the inside of the shell, (6) of the concrete at the center of the shell, and (7) of the concrete approximately 2 inches from the outside of the shell. The numbers in circles on the accompanying sketches represent these locations.

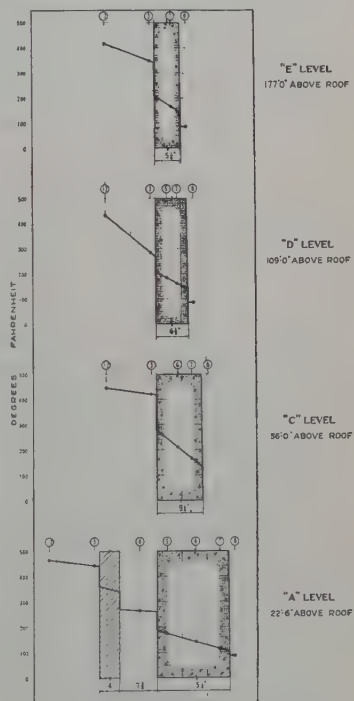
Readings were taken by means of "Copper-Constantan" thermocouples. Couples in the gas stream were inserted through iron pipes to hold them in their proper location, the couple being insulated from the pipe. For readings in the concrete, small holes were drilled directly into the concrete, the "hot junction" of the thermocouple inserted and the entire sleeve filled solid with plaster of Paris around the porcelain tubes which insulated the connecting wires.

Outside air temperatures were taken by means of a thermocouple mounted at level "E" and a thermometer on the roof near the base of the chimney.

It is a well-known fact that at the surface of a heat barrier there is a drop in temperature in the direction of the heat flow so that at the inside of the chimney shell there is undoubtedly a considerable drop from the temperature of the gas impinging against the concrete to the temperature of the concrete itself at its inner surface. The probable character of the temperature gradient is illustrated in one of the accompanying diagrams with abrupt drops in temperature at the surfaces of the concrete although, of course, the exact nature of this curve is somewhat conjectural.

The maximum stress due to temperature to be provided for in the design of the chimney is occasioned by the greatest difference in temperature in the concrete itself between its inner surface and the temperature reinforce-

ment. The tests show, as might be expected, that in general as the chimney shell becomes thinner the actual temperatures in the concrete near the outside face become greater, but that the difference in temperature between the inner and outer surfaces of the chimney shell becomes less. The readings also appear to show that as the chimney



PROBABLE CHARACTER OF TEMPERATURE GRADIENT
THRU CHIMNEY SHELL

shell becomes thinner the slope of the temperature gradient becomes flatter, whereas for practically unchanged temperature conditions the slope of the true gradient must be steeper as the chimney shell becomes thinner. This discrepancy may be due to the small radial distance between the points where the readings were taken, so that a slight

inaccuracy in the observed temperatures would materially affect the slope of the temperature gradient.

Tests of such limited nature cannot be taken as at all conclusive and there are many unexplained variations in the observed readings. However, until further experimental data on this subject is available, it is felt that for the purpose of designing reinforced concrete chimneys subject to conditions similar to those existing for the chimney under discussion, the general trend of the test data warrants the conclusion that the

maximum drop in temperature through the concrete of the chimney shell may be taken as:

(a) 20° F. per inch of shell thickness where the chimney is unlined.

(b) 10° F. per inch of shell thickness where the chimney is lined so as to furnish insulation equivalent to that of the lining in the chimney tested.

It is hoped that these tests will lead to further tests along the same line, and will result eventually in an accumulation of data from which still more positive conclusions can be drawn.

PROCEEDINGS

MINUTES OF MEETINGS

BOSTON SOCIETY OF CIVIL ENGINEERS

FEBRUARY 20, 1925. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, Boston, and was called to order by the President, Edwin H. Rogers, at 7.15 P.M. There were about 300 members and guests present.

This was a joint meeting of the Boston Society of Civil Engineers and the Northeastern Section of the American Society of Civil Engineers. The following student societies participated: M. I. T. Chapter, American Society of Civil Engineers; Harvard Engineering Society; Tufts Civil Engineering Society; and Northeastern University Section, Boston Society of Civil Engineers.

The reading of the minutes of the previous meeting were omitted as they will be printed in the February JOURNAL.

The Secretary announced the names of those elected to membership by the Board of Government today as follows:

Members: Paul L. Bean, Daniel E. Callahan, Raymond F. Connor, Edward A. Graustein, Raymond J. Leaver, Gun-

ner E. Leofquist and William M. Smith. *Juniors:* John H. Bowie, Thomas J. Conroy, Edward L. Davis, Jr., Frank K. Niechcay, Linn C. Fuller and Wilfred H. Shields.

The President announced the deaths of the following members of the Society: Willard Kent, died December 22, 1924; Charles H. Parker, died January 28, 1925; Frank P. McCarthy, died February 4, 1925. The President stated that committees would be appointed to prepare memoirs.

The President reported that the auditorium of the Boston City Club would not be available for the Annual Meeting on the regular date (March 18) and that the Board had recommended that the date of the meeting be postponed not more than one week. Upon motion of General R. K. Hale, duly seconded, it was voted that the date of the March meeting be postponed not more than one week, the exact date to be determined by the President and the Secretary.

Mr. Rogers then introduced Mr. Robert Ridgway, President of the American Society of Civil Engineers and Chief Engineer of the Board of Transportation of the City of New York, who gave an

illustrated talk on the "Rapid Transit System of New York City." At the conclusion of his paper Mr. Ridgway answered a number of questions concerning the construction of the New York subways. Upon the motion of Desmond FitzGerald, an Honorary Member of the Society, a rising vote of thanks was accorded Mr. Ridgway for his kindness in coming to Boston and presenting such an excellent paper.

Before the meeting, a smoker was held at which about 250 attended. Selections were played by an orchestra of the Northeastern University during the supper, and the Tufts College group sang a number of songs.

Meeting adjourned about 8.45 P.M.

J. B. BABCOCK, *Secretary*.

DESIGNERS SECTION

FEBRUARY 11, 1925. — The regular February meeting of the Designers Section of the Boston Society of Civil Engineers was called to order in Myers Hall, Tremont Temple, at 6.10 P.M., by Chairman Edward H. Cameron.

The subject for the evening was the presentation of papers by members. The first paper was "The Construction of the Neponset Bridge," by J. Stuart Crandall, Treasurer of the Crandall Engineering Company. Mr. Crandall was unable to be present but his paper was ably presented by R. H. Lindgren of his office.

The second paper was "Structural Design Features of a Hydro-Electric Development," by W. D. Henderson, civil engineer, of Jackson & Moreland. Mr. Henderson was unable to be present but his paper was ably presented by H. B. Perry of the same office.

The third paper was "The Design of Supports for Superimposed Chimneys for Power Houses," by Walter W. Clifford, of Clifford & Roebled.

The papers were illustrated by lantern slides. Interesting open discussions fol-

lowed the papers. There were 100 members and visitors present.

The meeting adjourned at 7.45 P.M.

WALDO F. PIKE, *Clerk*.

NORTHEASTERN UNIVERSITY SECTION

FEBRUARY 13, 1925. — A special meeting of the Northeastern University Section of the Boston Society of Civil Engineers was held at 7.15 P.M. this evening at the University, with Chairman Sidney S. Anthony presiding.

The Chairman introduced Mr. P. A. Shaw, chief engineer for L. H. Shattuck, Inc., Manchester, N. H. Mr. Shaw gave a detailed talk on the "Water Power Developments in New Hampshire," centering the major portion of his lecture upon the construction of the Marlborough Dam penstock and power house for the Keene Gas and Electric Company of New Hampshire.

With the aid of the reflectroscope, photographic views were thrown upon the screen showing clearly the details connected with the construction and development of a water-power project. A discussion followed the lecture. There were 30 members and visitors present.

The meeting adjourned at 9.00 P.M.

WILBERT H. CONNOR, *Clerk*.

HIGHWAY SECTION

FEBRUARY 25, 1925. — The annual meeting of the Highway Section was held in the Society Rooms at 6.15 P.M., with Chairman Arthur W. Dean presiding. The records of the previous meeting were read and approved.

The following were nominated for officers for the coming year: *Chairman*, Henry A. Varney, *Vice Chairman*, R. W. Coburn, *Clerk*, H. F. MacWilliams, *Executive Committee*, D. A. Ambrose, Joshua Atwood, F. H. Kendall.

On a motion, duly seconded, the clerk cast one ballot for the above nominees.

Adjourned 6.35 P.M.

A. B. APPLETON, *Clerk*.

APPLICATIONS FOR MEMBERSHIP

[March 15, 1925.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BURDEN, HARRY POOLE, Medford, Mass. (Age 35, b. Lynn, Mass.) Graduate of University of Maine in 1912, with degree B.S. in civil engineering. From July, 1910, to April, 1911, transitman; June, 1912, to September, 1913, chief of party; September, 1913, to July, 1918, instructor in civil engineering at Tufts College; summers of 1915, 1916, 1917 and 1920 resident engineer Massachusetts Highway Commission; July, 1918, to October, 1919, engineer in forest products, Forest Service, Madison, Wis., and Washington, D. C.; October, 1919, to September, 1922, assistant professor of civil engineering at Tufts College, and from September, 1922, to date, associate professor at Tufts College. Refers to Robinson Abbott, H. S. Boardman, J. S. Crandall, D. N. Peaslee, E. H. Rockwell, W. L. Vennard.

CAMPBELL, JAMES DANIEL, Boston, Mass. (Age 38, b. Mobile, Ala.) Graduate of high school. Entered business as timekeeper on general contract work

in the fall of 1903; in 1908 was assistant foreman on steel and concrete work, and about this time took a course in engineering with the I. C. S. of Scranton, Pa.; also in 1912 was general inspector of steel and concrete with the Grand Trunk Railroad in full charge of a new piece of road which they were building at that time; in 1913 was with the Phoenix Bridge Company as superintendent of erection, and remained with them until February, 1924; at present superintendent of erection with the Boston Bridge Works. Refers to M. F. Brown, J. E. Carty, H. M. Chadwick, R. R. Evans, N. E. Hadley, J. C. Moses.

CHATFIELD, RICHARD S., Newtonville, Mass. (Age 24, b. New Haven, Conn.) Graduate of Massachusetts Institute of Technology in 1922. From July, 1922, to September, engineer with Whidden-Beekman Engineering Company; September, 1922, to April, 1924, with Whidden-Beekman Company, builders and contractors, and from that date to the present with Whidden-Beekman Engineering Company. Refers to A. S. Coombs, D. C. Milne, L. J. Phillips, N. P. Randlett.

DINGWALL, JOHN CONNELL, North Weymouth, Mass. (Age 25, b. North Weymouth, Mass.) Graduate of Tufts College, with degree B.S. in civil engineering. For a year and a half was with the Bethlehem Shipbuilding Corporation; since graduating has been engineering assistant in the State Highway Department, and at present is employed by the Boston & Maine Railroad as structural draftsman. Refers to Robinson Abbott, B. W. Guppy, H. F. Heald, Pusey Jones, E. R. McCarthy, R. H. Whiting.

FREEMAN, WILLIAM M. BREakey, Brookline, Mass. (Age 28, b. West Orange, N. J.) Graduate of Massachusetts Institute of Technology, 1921, with degree of B.S. in civil engineering. July, 1919, and June, July, 1920, with the Boston & Albany Railroad in the bridge department; 1921-24, with investment bankers; from April, 1924, to December, 1924, was manager for John E. Quinn, and duties consisted of estimating, getting business and managing work. At present with New England Foundation Company, Inc. Refers to J. B. Babcock,

C. B. Breed, F. T. Flynn, J. J. Rourke, A. C. Titcomb, W. A. Woods.

HERSUM, LEROY MAXWELL, Auburn-dale, Mass. (Age 26, b. Weston, Mass.) Attended Norwich University, 1917-18, taking civil engineering course; attended Massachusetts Institute of Technology, 1918-21, receiving degree B.S. in civil engineering in January, 1922; also a graduate of the basic course, 1918, and battery officers' course, 1922. During the last eight years have had experience as transitman with W. A. Mason & Sons; from June, 1922, to August, 1923, was assistant in the Massachusetts Department of Highways; assistant engineer on a hydro-electric report for the Vaughan Engineers, draftsman and designer on concrete for Stone & Webster, January to June, 1924, and resident engineer, later as designer in Division of Bridges, Department of Public Works, from June, 1924, to date. Refers to R. W. Coburn, C. A. Mason, F. H. Morris, J. H. O'Connor, M. P. Smith, Sydney Smith.

RANEY, WALTER A., Lowell, Mass. (Age 27, b. Lowell, Mass.) From 1916-19, rodman, transitman and chief of party, also draftsman in private surveying office; from 1919-21, chief of party and engineering assistant in city engineer's office, Medford, on sewers, water, paving bridges, location surveys, etc.; from 1921-22, in charge of office of F. W. Huntington & Co., Lowell; 1922 to the present, assistant engineer with the Massachusetts Highway Commission, acting as resident engineer on road projects. Refers to A. B. Appleton, H. F. Heald, F. W. Huntington, A. P. Rice, H. E. Warren.

THERIAULT, JOSEPH EDWARD, Watertown, Mass. (Age 30, b. Newton, Mass.) A junior at Northeastern University. During work periods has been with the Boston & Albany Railroad, the J. R. Smith Construction Company, and in surveying with a graduate of Northeastern University in spare time for two years making surveys for building lots, dispute lines and factory sites. Refers to H. P. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

WRIGHT, EDWIN H., Tufts College, Mass. (Age 41, b. Charlestown, Mass.) Graduate of Tufts Engineering School,

with degrees of B.E.E. and B.S. in 1894. In the fall of 1894 entered the office of Walter J. Paine, architect, as draftsman; from that time until September, 1918, engaged in architectural and structural work; with Putnam & Cox for about sixteen years; appointed instructor in civil engineering at Tufts College, September, 1918; assistant professor, 1919; associate professor, September, 1923, and acting head since resignation of E. H. Rockwell, Refers to Robinson Abbott, E. S. Dorr, H. S. French, C. R. Gow, E. H. Rockwell, H. T. Stiff.

NEW MEMBERS

Members

- PAUL L. BEAN, 145 Davis Ave., Auburn, Me.
 RAYMOND F. CONNOR, 11 Winthrop Pl., Medford, Mass.
 EDWARD A. GRAUSTEIN, 6 Beacon St., Boston, Mass.
 RAYMOND J. LEAVER, 49 Swan St., Lawrence, Mass.
 GEORGE E. LOEFQUIST, 8 Maple Ave., Cambridge, Mass.
 WILLIAM M. SMITH, 20 Carver St., Cambridge, Mass.

Juniors

- GEORGE E. BERTINI, 27 Woodville St., Everett, Mass.
 JOHN H. BOWIE, 12 Webster Rd., East Milton, Mass.
 THOMAS J. CONROY, 19 Vista St., Roslindale, Mass.
 CARL B. EMERY, 30 Chestnut St., Malden, Mass.
 DANIEL C. FROST, 315 High St., Newburyport, Mass.
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 GEORGE A. MCKENNA, 27 Gilbert St., Waltham, Mass.
 CARL H. NELSON, 82 Everdean St., Dorchester, Mass.

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CHARLES T. PLATTER, 11 Billerica St.,
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MORRIS RUBIN, 83 Ruthven St., Rox-
bury, Mass.

WILFRED H. SHIELDS, 181 Sydney St.,
Dorchester, Mass.

JAMES W. URQUHART, 51 Orange St.,
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ROGER G. WITHERELL, 487 Tremont St.
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BOSTON SOCIETY OF CIVIL ENGINEERS

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INDEX TO ADVERTISERS

	PAGE
ADAMS, H. S., 100-1 Ames Building, Boston	iii
ASPINWALL & LINCOLN, 46 Cornhill, Boston	iii
ASSOCIATED ARCHITECTS PRINTING & SUPPLY CO., 25 Pearl St., Boston	x
BARROWS, H. K., 6 Beacon St., Boston	iii
BAY STATE DREDGING AND CONTRACTING CO., 62 Condor St., East Boston	x
BEATTIE, ROY H., 209 Bedford St., Fall River	ix
BISHOP, J. W., & Co., 683 Atlantic Ave., Boston	iv
BLAIR, ISAAC, & Co., INC., 433 Harrison Ave., Boston	xiv
BOSTON BRIDGE WORKS, INC., 47 Winter St., Boston	xiv
BOSTON INSULATED WIRE & CABLE CO., Dorchester	xv
BRUNO & PETITTI, CONTRACTORS, 18 Tremont St., Boston	iv
CLIFFORD & ROEBLAD, 101 Tremont St., Boston	iv
COLEMAN BROS., 245 State St., Boston	ix
CONANT MACHINE CO., Concord Jct., Mass.	ix
CRANDALL ENGINEERING CO., 102 Border St., East Boston	xi
EARNSHAW, H. P. J., 99 Chauncy St., Boston	ix
EASTERN BRIDGE AND STRUCTURAL CO., Worcester	viii
ELECTRIC BLUE PRINT CO., 36 Bromfield St., Boston	ix
FAY, SPOFFORD & THORNDIKE, 200 Devonshire St., Boston	iii
FULLER & MCCLINTOCK, 170 Broadway, New York	iii
GIANT PORTLAND CEMENT CO., Philadelphia, Pa.	xv
GOW, CHAS. R., Co., 957 Park Square Building, Boston	vi
GRANITE PAVING BLOCK MFRS' ASSOC., 31 State St., Boston	xiii
GRID FLAT SLAB CORPORATION, 568 Columbia Rd., Boston	xii
HALL, JOHN G., & Co., 114 State St., Boston	ix
HOLBROOK, CABOT & ROLLINS CORPN., 6 Beacon St., Boston	vi
HOLZER, U., INC., 333 Washington St., Boston	vii
JACKSON & MORELAND, Park Square Building, Boston	iii
KEATING, P. J., COMPANY, 280 Main Street, Fitchburg, Mass.	xvii
LEIGHTON-MITCHELL CO., 99 Chauncy St., Boston	xv
MAIN, CHARLES T., 200 Devonshire St., Boston	ii
MAKEPEACE, B. L., INC., 387 Washington St., Boston	xii
METCALF & EDDY, 14 Beacon St., Boston	iii
MONKS & JOHNSON, 99 Chauncy St., Boston	iv
NEW ENGLAND FOUNDATION CO., INC., 120 Tremont St., Boston	ix
OLD CORNER BOOK STORE, 50 Bromfield St., Boston	ix
PALMER CO., INC., JOHN E., 1012 Old South Building, Boston	ix
PENNSYLVANIA CEMENT CO., 161 Devonshire St., Boston	viii

	PAGE
PERRIN, SEAMANS & Co., 57 Oliver St., Boston	vii
PORTLAND STONE WARE Co., 49 Federal St., Boston	v
RIDEOUT, CHANDLER & JOYCE, 178 High St., Boston	ix
ROCKPORT GRANITE Co., Rockport	v
ROWE CONTRACTING Co., Centre St., West Roxbury	vii
SCULLY Co., 118 First St., Cambridge	xv
SIMPSON BROS. CORPN., 77 Summer St., Boston	v
SMITH, B. F., & Co., Merchants Bank Building, 79 Milk St., Boston	ix
SPAULDING-MOSS Co., 42 Franklin St., Boston	xiv
STANDARD OIL CO. OF NEW YORK, 31 St. James Ave., Boston	xvii
STONE & WEBSTER, INC., 147 Milk Street, Boston	xvi
STUART, T., & SON Co., Newton, Mass.	xi
THE THOMPSON & LICHTNER Co., 80 Federal St., Boston	iii
THORPE, LEWIS D., 200 Devonshire St., Boston	iii
TUCKER, EDWARD A., Co., 101 Milk St., Boston	iv
WALDO BROTHERS AND BOND Co., 202 Southampton St., Boston	viii
WARREN FOUNDRY AND PIPE Co., 201 Devonshire St., Boston	vii
WESTON & SAMPSON, 14 Beacon St., Boston	iii
WHITMAN & HOWARD, 220 Devonshire St., Boston	iii
WORCESTER, J. R., & Co., 79 Milk St., Boston	iii
WRIGHT & POTTER PRINTING Co., 32 Derne St., Boston	x

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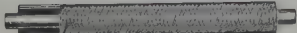
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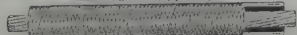
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